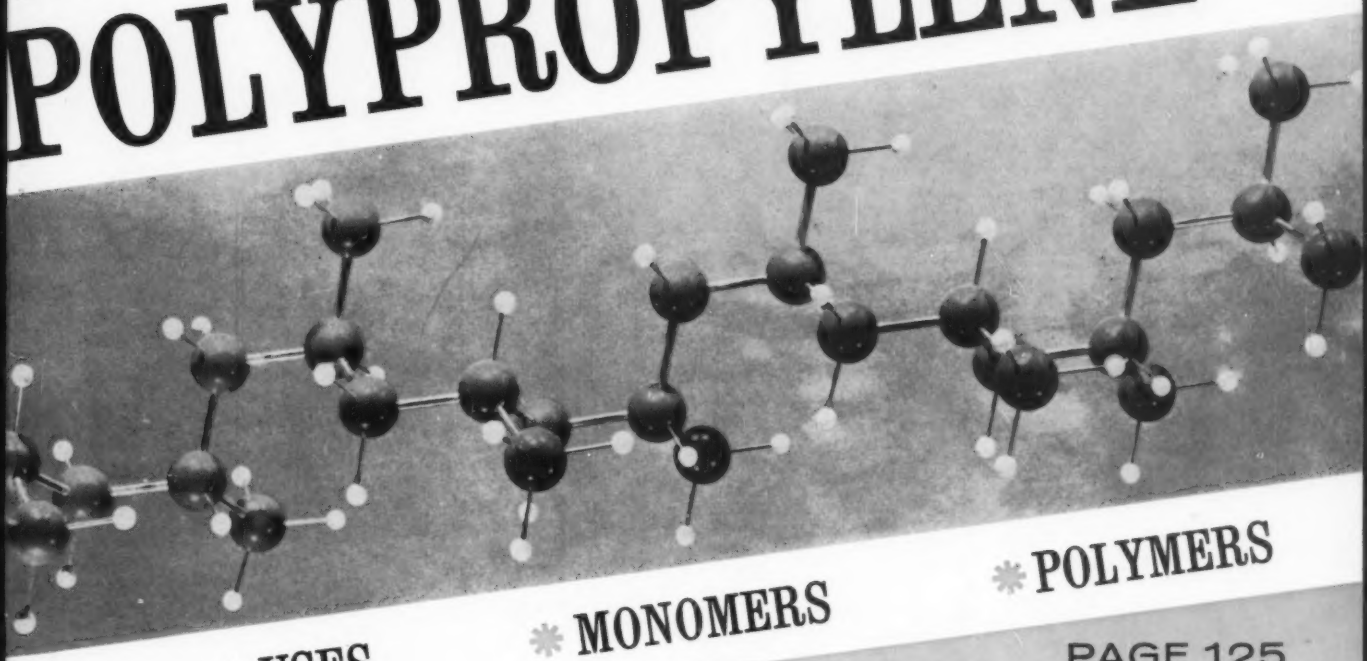
MARCH 1961

Petroleum REFINER

FOR THE HYDROCARBON PROCESSING INDUSTRY

A SPECIAL REPORT

POLYPROPYLENE



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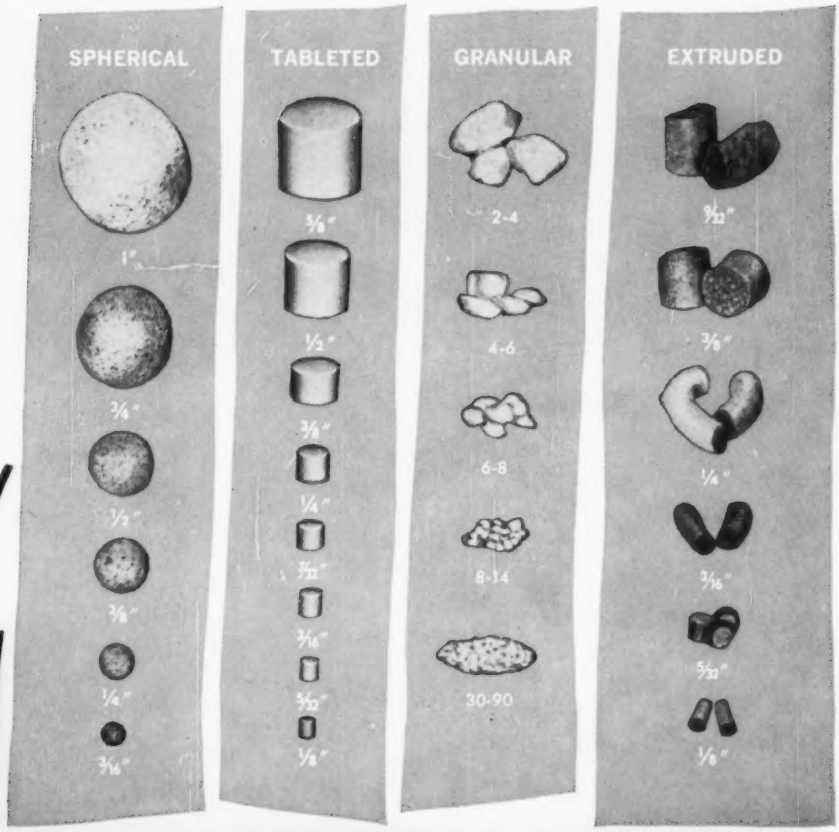

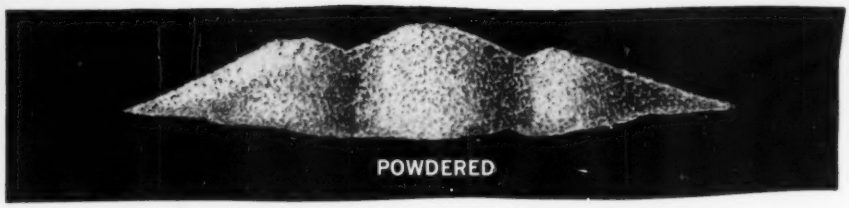

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Petroleum
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FOR THE HYDROCARBON PROCESSING INDUSTRY
A Gulf Publishing Company Publication

A Quick Look

at this issue

These handy digests permit checking ☑ the articles you want to read first.

POLYPROPYLENE SPECIAL REPORT

☐ **New Uses Spark Polypropylene Growth . . .** Some sharp trading in raw materials for established products is likely to result from growth sparked by new uses of propylene. High purity propylene has some unusual cost factors. For these and a complete story on use patterns, turn now to **Page 125.**

☐ **How to Make Polypropylene . . .** This interesting article gives you important data regarding operating conditions, catalysts and processing techniques. For a real insight into this important new polymer, be sure you turn to **Page 129.**

☐ **Why Polypropylene Uses Will Grow . . .** Because of its physical properties and exceptional versatility, polypropylene is assured of a steady growth. You will learn just where these areas of most rapid expansion are by reading this complete analysis of present and future markets. Turn to **Page 137.**

☐ **Keep Equipment Cost Data Current . . .** Here's a good method for building your own process equipment estimating file. You'll want to clip this introduction to the new series "Equipment Cost Data File," which starts on **Page 143.**

☐ **Analyze Plant Control by Transient Response? . . .** A heat exchanger example in this interesting article shows the transient response method is as good as the frequency response method for determining controller settings. You'll see how a simple equation derived for computer control compares favorably with actual response, when you turn to **Page 145.**

☐ **Watch Japan's Petrochemical Growth . . .** By taking a look at Japan's petrochemical industry through selected highlights in this article, you can determine for yourself areas of excess production, present plant selection and scheduling of future plants. For a close look at one of your competitors, see **Page 149.**

Please Turn Page ➡

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A Quick Look at This Issue . . .

☐ **Still Growing Fast . . . Chlorinated Hydrocarbons . . .** New demands for allyl chloride, new high polymers, and that old standby vinyl chloride, are contributing to the continued fast growth of chlorinated hydrocarbons. For a quick look at past predictions and some future ones, turn to **Page 155.**

☐ **Revised Guide to ASME Vessel Code . . .** Here's a graphical index to the 1959 ASME Boiler and Pressure Vessel Code. This will illustrate some of the types of pressure-vessel construction provided for under section 8 of the code. It will also furnish direct references to the code rules applying to these construction features. For your copy of this up-to-date, handy guide, turn to **Page 160.**

☐ **Nomographs Speed Vessel Design . . .** Using these handy nomographs, the designer will be able to quickly solve the more common design formulas in the 1959 ASME Boiler and Pressure Vessel Code, Section 8. To see how they work, turn to **Page 162.**

☐ **Find Equilibrium Constants Graphically . . .** This article gives nomograms which relate chemical equilibrium constants at any temperature to the heat and free energy changes for reactions in the standard state. To clip this for use in exploratory calculations, turn now to **Page 163.**

☐ **Find Pipe Pressure Drop by Nomograph . . .** Using this new type of nomogram, you can easily and quickly find pipe pressure drop. Five important functions of line sizing can be easily performed, and friction factor varied to suit your individual needs. To clip this for your workbook, turn to **Page 169.**

☐ **How to Evaluate Chemical Projects . . .** This useful article gives an example of how each of the important variables of costs and revenues affect the profitability of proposed projects. You'll find it packed with data you can use every day. Turn to **Page 171.**

☐ **Why Atlantic Used Armor Cable in Division 2 Areas . . .** Approximately 25,000 feet of interlocked armor cable in aluminum trays was used in Atlantic's new wax plant. Why? Because cable cost was 15 percent lower than conduit and wire. Cost of the entire cable tray system was almost covered in cable-cost savings alone. Although overhead cable installations are not approved by NEC, the refining industry recognizes them as comparable to conduit and wire. To see how Atlantic and Badger did it, turn to **Page 177.**

☐ **Thermo Data for Petrochemicals . . . Part 27 . . .** This article thoroughly covers gaseous normal aldehydes. Here are the important thermo data for all the normal aldehydes from formaldehyde down to the decaldehydes. If you need tabulated data on specific heats, enthalpies, entropies, free energies and so on, then turn to **Page 181.**

☐ **Choose the Right Floating Roof Tank . . .** Selecting the right floating roof involves three decisions: How much money can you spend? How much protection do you need against sinking or tipping and buckling under load? And, how close must you control evaporation losses? To answer these questions, and to be sure you're selecting the right floating roof, turn to **Page 185.**

☐ **Solubility of Cyclopropane in Water . . .** No solubility data for cyclopropane in water have been found in the literature. But this article shows results of an experimental determination for pressures up to 620 psia and a temperature range of 70 to 220° F. For this valuable information, be sure to see **Page 191.**

☐ **Use Computer to Size Relief Valves . . .** The repetitive nature of relief valves calculations makes them easy to process on a digital computer. Programing costs on the computer can be paid out after only 60 valve calculations. For a detailed article on setting up the mathematics of the computer program, turn to **Page 193.**

☐ **How Well Can You Rely on Lab Tests . . .** To know now close to specification limits you can safely blend your products, you need to know the reliability of laboratory tests. Here is a way to evaluate these analyses. Turn to **Page 201.**

☐ **Newest Helium Plant: How It's Working . . .** From the first nine months of operation, the Bureau of Mines plant at Keyes shows a 91 percent helium recovery and a cost of $9.11 per Mcf of helium. In this informative article, you can see several process and equipment improvements over the older helium plants. To learn what these improvements are, turn now to **Page 205.**

☐ **Liquid Viscosities of Petroleum Fractions at High Pressures . . .** At last someone has come up with a simple graphical correlation which will give you the effect of pressure on viscosities of liquid petroleum fractions. It's simple to use, and you're sure to use it. Turn to **Page 209.**

☐ **Rapid Reading . . . Part 2 . . .** Let's face it—technical reading is tough reading, but it *can* be made much easier with new techniques. What's more, technical material can be easily recalled *after* reading. Be sure you learn how by reading Part 2 of the Rapid Reading series beginning on **Page 213.**

☐ **Tips for Turnaround Ventilation . . .** Ventilation can't turn a turnaround into a hard-hat haven, but it can relieve some of the headaches which refiners and their men face when process equipment needs "hot work" inside. For an interesting and informative analysis of ventilation problems and how they can be solved, turn to **Page 217.**

Improve your Engineering I.Q.*

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Train yourself and others in supervisory techniques for professional advancement

Popular thinking on any subject is often like a pendulum, swinging forward in sheer exhilaration over an exciting idea, then backward to a cynical attitude against it. Years ago, health columnists extolled the nutritive qualities of spinach. Shortly thereafter, it was equally popular to decry spinach as an overglamorized weed.

This vacillation springs from the efforts of spokesmen to capture interest, and the tendency of many people, like wild creatures in the forest, to give attention to whatever is moving regardless of the direction. That is why it sometimes seems that the more preposterous an idea the more credence it receives.

World War II, with its demands for hundreds of thousands of leaders to be developed quickly, accelerated the concept of training men in human relations. Many veterans tried, after the war, to apply the principles to industry. Supervisor and management development became extremely popular. Some of these programs naturally fell short of expectations, and there are always detractors — ready to display their intellectual brilliance by speaking cynically of *all* types of human relations training. Real progress in supervisory methods has, therefore, been slow.

Supervisory personnel, continually aware of the intrinsic values of human relations, are the key to uninterrupted production, completion of projects successfully and on time, for they forge the links in the productive chain solidly together.

Your management is interested not only in the creative, bold steps you would take into unknown solutions to problems, but also in how quickly and productively (profitably) you can put these ideas into practical application. When the solution, or idea, leaves your desk and starts down the long line of being put into practice, supervisors throughout that chain of action and their relationships with those about them — will determine to a great extent whether their individual components will function properly or whether a project will bog down under the weight of misunderstanding and apathy.

It signals to the engineer in charge, therefore, the importance of maintaining good supervisory practices throughout the various departments through which the original concept must be translated. It means a thorough understanding of human relations yourself, and the ability to communicate this understanding and appreciation to the supervisory personnel under you. This can and probably must be done both by individual contact with your supervisors and/or by conducting actual courses of study on the subject.

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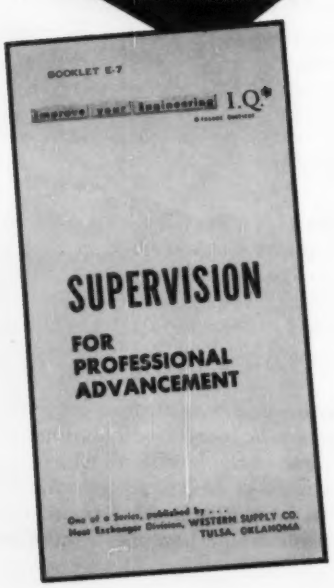
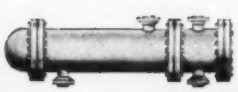


. . . the foregoing paragraphs are a direct quotation from another of Western's personal-professional-development series, copies of which are available upon request at no charge. Western's conviction about the importance of competent supervisors as an adjunct to efficient engineering work is founded upon direct observation in our own plant, where trained supervisors contribute greatly to the manufacture of heat exchangers of the highest quality, and where personal attention to detail is their watchword. We invite your inquiry when heat transfer problems arise.



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PIPE LINE INDUSTRY and The PIPE LINE CATALOG for the oil and gas pipe line industry.

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After 20 Years

HOW MANY ITEMS on your list of purchases can be bought at the same price you paid in August 1941? Very, very few, if any would be the considered answer. A subscription to PETROLEUM REFINER was in that category up until March 1 of this year when the yearly rate went from $2.00 to $3.00. Because the last time there was any advance was in the good prewar month of August 1941 when the $1.00 subscription price was abandoned.

We've often had our say about what a bargain HPI men get when they subscribe to PETROLEUM REFINER and there's no reason to change that spiel now. Because at $3.00 per year it doesn't take many of the articles—and there are more than a dozen every month—to get your money back. And the bargain gets even better if you sign up for two years ($5.00) or for three years ($6.00).

A Man Is Known

JUST AS A MAN is known by the company he keeps, PETROLEUM REFINER is known by the companies that keeps its authors. A new study shows the various companies whose employes have contributed articles to PR from 1956 through 1960. A rundown on these contributor companies for this five-year period shows:

Company Category	No. Companies	No. Articles
Oil and Gas	69	326
Chemical	41	155
Engineer-Constructor	42	166
Equipment and Service	75	117
Universities, Consultants, Govt. Bureaus, Private Laboratories & Miscellaneous	—	267

And though the content of the articles is the main thing, PR is mighty proud to have this wide yet selective distribution of authors among these company categories.

Editor George Gibbs works the year 'round toward making PR's Special Report on Gas Processing an extraordinary addition for the files of those connected with that quite busy segment of HPI. Articles he has lined up for next month's issue include one on modernization to increase propane recovery, another on removal of CO_2 from natural gas, and still another on costs and profits of nitrogen removal. Maintenance and inspection topics also are accorded space. An added feature—as though one is needed—will be the publication of the best papers from the NGAA's annual meeting. Alert yourself for the April issue!

If for any reason you need a separate of PETROLEUM REFINER's 1960 Annual Editorial Index, the way to get a copy is this simple: Address a request to Librarian, PETROLEUM REFINER, Box 2608, Houston 1, Texas. Most readers find that the index bound into the December issue meets all their needs, but we do have the separates—and free—for any others.

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Quick Look at Industry...

Eyeing the Big Chemical Picture . . .

Chemical imports making steady gains in U.S. economy as Japanese and Western European industry expands. Still, U.S. is leading chemical producer—exports are three times chemical imports. Advanced industrial nations likely to become much stronger in chemical picture. Their property demands on raw materials and markets away from home giving them strong desire to export.

The bright side: U.S. producers can look for continued demand for upgraded products, such as special grades of polyethylene. Also, high industrial capacity in advanced nations generates demands for chemicals not yet supplied locally. The dark side: European Common Market, free from tariff barriers to members, will be major obstacle for U.S. exports.

Panning Processing Profits . . .

Refining profits look good for first quarter 1961. Cold weather helped, but real basis is corrective measures taken last year by industry. Domestic integrated companies probably will do even better in mid 60s, say some experts. But those with heavy investments in foreign operations are in for less profits in same period.

Gulf Coast to Ease Off on Petrochemicals? . . .

Though Gulf Coast's share of petrochemical plant investment has increased to 60%, some experts don't think trend will continue. Reason: Cost of construction, fuel and labor will approach that of rest of nation. Midwest and East Coast have transportation advantage over Gulf in supplying ultimate petrochemical user. Most promising area: New Jersey.

Study Reveals "Emergency" Capacities . . .

Big part of refinery capacity would be limited to less than 90 days operation if restricted to in-plant inventories of process chemicals during emergency, says new NPC-study report. Natural gasoline plants would be less limited by process chemicals. Story is just opposite for maintenance supplies. Only small percentage of refinery capacity would be limited to less than 90 days production using only in-plant maintenance materials. But big part of natural gasoline plant capacity would be held to less than 90 days operation.

About Private Enterprise and Helium . . .

New helium conservation bill effective this month involves building helium extraction plants on gas transmission lines. Interior Department will encourage private industry to finance, build and operate plants. Considerations: Belief that no key helium discoveries will be found in U.S., and best way to use available helium is to take it from natural gas on way to market. For detailed technical and cost data, don't miss PETROLEUM REFINER's Special Report on the new Keyes plant, beginning on page 205, this issue.

Fuels Regulation for Europe? . . .

Energy market competition in early 1960s may lead some Western European nations to take fuels regulation restrictive measures in interest of

own fuel industries, says Oil Committee of Organization for European Economic Cooperation. Intervention may be needed, especially if excessive short-term could cause long-term harm to nation's economy, says committee.

Scanning the Process and Product Scene . . .

New ultra-high-temperature petrochemical process developed by Richfield Oil and MHD Research, Inc. Technique, based on plasma arc, gives high temperatures (up to 60,000°F) and high enthalpies (up to 50,000 Btu's a pound) . . . Waste water treatment process developed by Sun Oil permits re-use of some refinery waste-water streams as cooling tower make-up water.

Celanese up with acetal copolymer plastic with strength and heat-resistant properties of some metals (more on Page 263) . . . New dealkylation processes for making benzene from aromatic refinery products almost ready for commercial use. Processes being worked on by Sun, Humble, Union and Tidewater.

Merging the Old and Forming the New . . .

Standard of Indiana forms Amoco Australia, Ltd., as refining and marketing subsidiary in Australia . . . Dow Chemical sets up new laboratory for instrument systems research (more on Page 267) . . . Tennessee Gas Transmission establishes new company, Tenneco, to handle all non-regulated TGT enterprises, including refining . . . Amoco Chemicals and Pittsburgh Chemical form Oxo Chemicals to build isooctyl and decyl facilities in Ohio.

No Reason to Rejoice in Residual Camp . . .

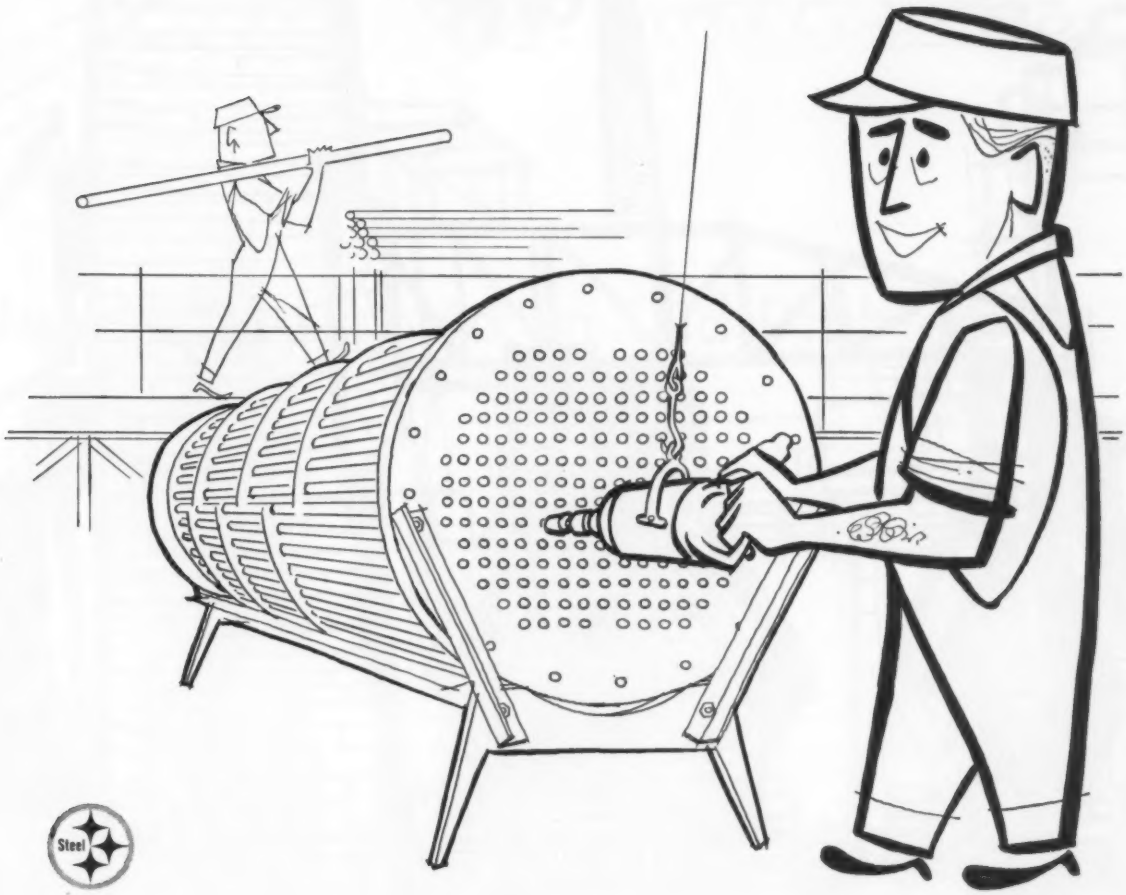
Long range picture for residual fuel oil is no better than for last 5 years. In this period, demand dropped 0.3%, mostly because gas took new industrial markets, and transportation use declined. As gas becomes more available in East and on West Coast, demand expected to decline further. Some experts say gas price has been too low in postwar period.

Resid market in marine propulsion likely won't be affected much by nuclear power in next decade, even though naval vessels expected to change over. Experimental vessels, like Savannah, show no economic advantage for nuclear power.

Quick Look Around the World . . .

Nine die in explosion and fire at Phillips Petroleum's Borger, Texas refinery. Blast caused by broken pipe line, say company officials . . . Four consecutive explosions at Ethyl's Baton Rouge plant kill 2 employes, hurt 32 others. Two 5-story chemical units destroyed . . . Pemex stops most construction work on huge Mexican petrochemical complex. Speculation has it that big government-owned company is in financial trouble . . . Interior Secretary Udall appoints self co-chairman of NPC, succeeding Capt. M. V. Carson.

Amoco's Whiting refinery to lay off 450 workers before end of year because of "modernization" program . . . Justice Department trustbusters taking closer look at "joint venture", which is getting more and more popular as avenue of HPI corporate growth.



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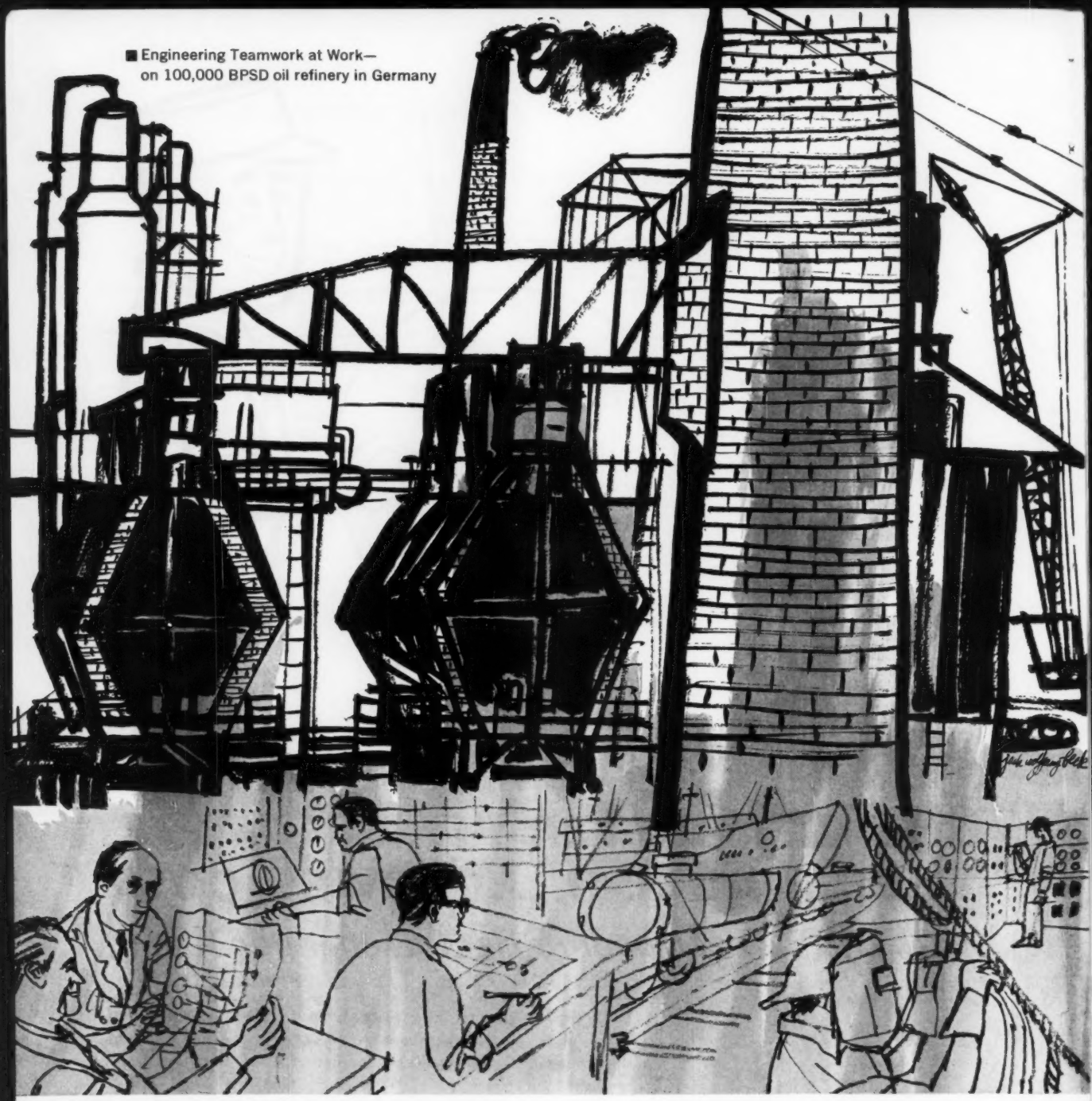
For more data on advertised products, use Readers' Service Cards, last page.



■ Engineering Teamwork at Work—
on 100,000 BPSD oil refinery in Germany

NEWEST RHINELAND REFINERY

A major contribution to West Germany's dynamic industrial growth is the giant new grass roots refinery of BP Benzin und Petroleum A.G. at Dinslaken. When fully completed, in 1961, it will increase the Republic's domestic source of gasoline, oil, and other petroleum products by 100,000 BPSD.

A huge and complex undertaking, this new refinery is the result of close coordination of effort among American, British, and German engineers. Each is making important and specific contributions to the over-all project.

Advisory and consultant services are being rendered BP in Germany on many phases of the undertaking by Kellogg Refinery Consultants, Ltd., Dusseldorf. These include procurement of materials and equipment, construction, operator training—as well as advice to BP Benzin und Petroleum A.G. on the testing and start-up of its refinery. Most of the materials and equipment have been supplied by German industry.

Fried. Krupp, Industriebau has worked closely with Kellogg on the project from inception through construction.

If you are planning to build new processing facilities at home or abroad, Kellogg would be glad to show you how its coordinated engineering-procurement-construction services could work to your company's economic advantage. Please address inquiries to The M. W. Kellogg Company, 711 Third Avenue, New York 17, N. Y.

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M KELLOGG W

New Approach to an Old Problem

A THREE-MAN TEAM of "public" advisers is helping Kaiser Steel and United Steelworkers of America negotiate and discuss labor-management problems with a minimum of personal bias. When the near disastrous 1959 strike (104 days) dropped management-labor rapport in the steel industry to an all-time low, the parties to that strike set up a Long-Range Committee. This team of three disinterested but well-informed citizens is to bring in the "outside" viewpoint. It is planned to ease tempers and personal antagonisms that blind reason. The ultimate goal: to bring management and labor into closer harmony.

Not Professionals. Mind you, these three persons are not arbitrators—not mediators—just three intelligent citizens who can analyze points of conflict without bias or fear of personal jeopardy. Revolutionary idea? Yes, but Kaiser Steel says it is achieving remarkable results. The company says "the . . . committee has worked cooperatively and progressed toward achievement of the objectives established for it . . . It will be used on a continuing basis to promote harmonious labor relations between the parties."

Under the new strike prevention procedure, the company and union will invite public members of the committee to assist them during future contract negotiations. If necessary, they will take steps to resolve deadlocks that may result in strikes.

The agreement provides that labor and management would meet for collective bargaining no later than 60 days before expiration of their current contract. Thirty days before contract expiration, the Long-Range Committee would review the status of negotiations.

A 'Working' Arrangement. Public members of the committee would then be authorized to take any or all the following steps:

(1) Determine to take no action or to postpone action until there has been an opportunity for further collective bargaining.

(2) Attend the collective bargaining sessions as observers.

(3) Engage in mediation efforts, including private consultation with representatives of both parties.

(4) Issue a private report to the parties summarizing the positions of the parties, defining the issues in dispute, and making recommendations to the parties for terms of settlement.

(5) Issue a public report, either before or after the contract termination date. Public members shall not release a public report until the company and union have had every opportunity to reach an agreement.

It would not be a bad idea for more companies to follow Kaiser Steel's example, and set up a Citizen's Committee. For one thing, parties to a dispute could avoid reliance on deadline pressures through timely suggestions and recommendations during the entire course of a contract. The fact that the Kaiser committee does not handle specific grievances makes it possible to do this without outside distraction.

After all, it is true we sometimes get so bogged down in detail that we can't see the big picture—the proverbial forest for the trees. And professional arbitrators arbitrate so much—they're subject to this native human weakness too.

Keep Government Out. Up to now, the alternative to collective bargaining has been government intervention. But government action poses many problems, including eventual impairment or displacement of collective bargaining. And, of course this would be disastrous. We're close enough to socialism as it is.

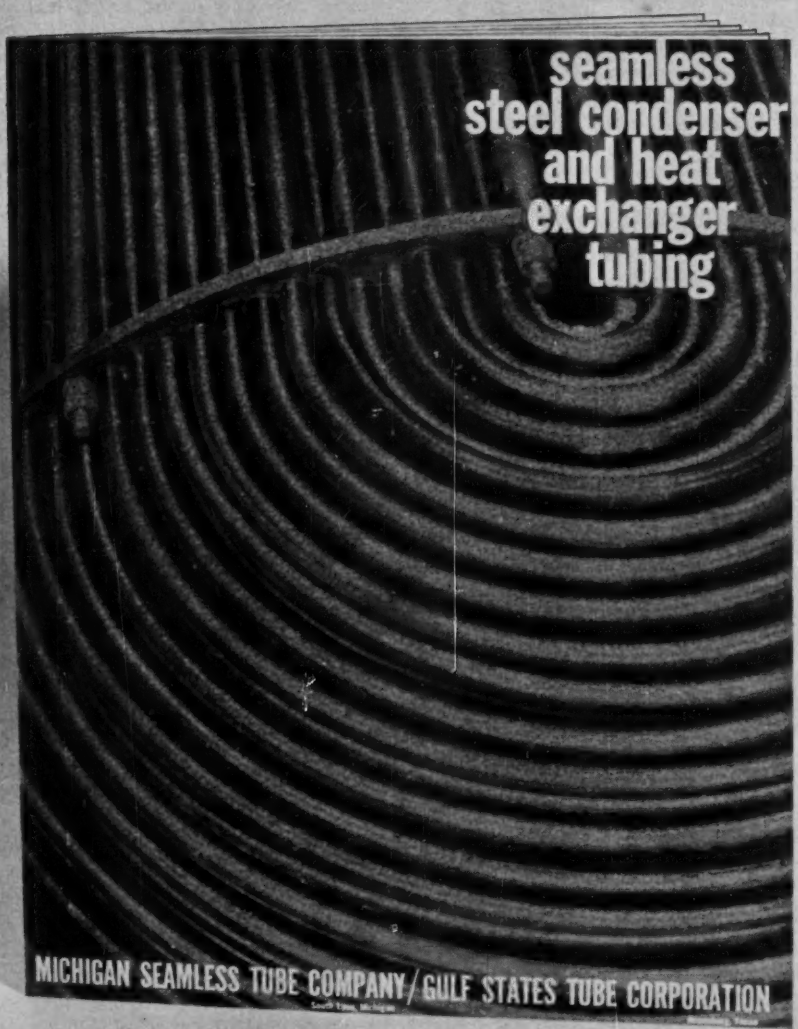
Kaiser may have hit upon something worth taking a close, hard look at—an assistance to collective bargaining that is not imposed but agreed upon. Given the help of experienced persons in whom the parties have confidence, the success of collective bargaining can be enhanced while keeping the freedom of decision needed in any kind of negotiation.

Won't Replace Collective Bargaining. The public Committee system being tried in this international steel corporation is not intended to replace free, responsible collective bargaining. Neither the union nor the company is bound by committee recommendations.

What Kaiser is doing may progress from the idealogical to the ideal. Only time will tell. But in the meantime, it's gratifying to see divergent parties still willing to keep an open mind by accepting informed assistance. This sort of thing has made America great.

catalog no. 261 just published.

packed with useful data. write for your copy!



MICHIGAN SEAMLESS TUBE CO. south lyon, mich.

Gumption To Take a Hand

ARE YOU CONTRIBUTING to the destruction of our freedoms through your own selfishness, expediency, and complacency? Because many of us do not have the gumption to take a stand in governmental affairs we are slowly helping to flush our freedoms down the ever-prominent rathole of Communism.

In essence, this is what Willard M. Wilson, secretary of the American Petroleum Institute, told the Illinois Industry Convention in a talk last September that won him the top national award from the Freedoms Foundation in the public address category.

Wilson declared that "We will become blank numbers in a calculating machine behind the Iron Curtain," unless we have the courage to take a stand on fundamental issues — issues essential to the preservation of our freedoms.

"Freedom is not a one-way road. It carries with it responsibility. Rights cannot be claimed unless duties are, at the same time, recognized."

What, then, do you say about our freedom? Is it something that we take entirely for granted? Do we neglect to preserve our rights? Do we destroy its full worth by not taking full advantage of it?

Many believe that **one** man can not stand alone to preserve our freedom. API's Wilson answers that "We each have the power of one, multiplied by thousands who are willing to take a stand."

Penny Pinching In Research

THERE ARE COMPANIES in the hydrocarbon processing industry that may want to check their procedures to determine whether in the matter of research they are following a "penny wise, pound foolish" policy.

"If we are going to continue to be 'top dog' in petroleum research and also compete with companies doing chemical research, we have to be manned with highly competent and alert people, have good facilities, be effectively organized and conduct our research with maximum efficiency." These are the words of Carl Tongberg, executive vice president, Esso Research and Engineering Co.

Tongberg, who was quoted at an employe orientation meeting, went on to say that ". . . we obviously have to do our research at minimum cost. This is important for several reasons. A saving of $1 million in operating costs could be used to add about 20 technical men with all of their needed support to our staff and thereby permit us to tackle several major new research projects. This would improve our competitive position."

Other companies, too, are probably trying to cut costs in research—trying hard, but just like any other business, in the HPI or not, they probably will be, or have been, caught in the contemporary phenomenon known as the "profit squeeze." Sales volumes are up, but costs are high and prices are low. Hence the drive to cut the cost of operation.

Management today often feels that it is not receiving full value from the companies' research and development activities. Company officials are wondering whether the investment in research personnel and equipment is as productive as the corresponding dollars put into production and sales. A 1960 survey by the National Science Foundation of 110,000 researchers disclosed that half of the number earned more than $9,000. Salaries reported ranged from a low of $6,000 to a top of $15,000.

As "Mobil World," a Socony Mobil Oil Co., Inc., publication, had to say, "The real aim of cost control is the question of waste vs. profitable use of money." The publication put the cost-control problem in another light: the conservation of money. It defines conserving money as being a vastly different concept from pinching pennies. Pinching pennies implies nonspending. Money conserving implies non-wasting.

The Mobil house organ compares the conservation of money with that of oil. Conservation of oil, in its briefest sense, means making the best use of oil. The conservation of money means making the best use of money—the wisest, most profitable use of the dollars you have to spend. So, in the matter of research—

Are you pinching your pennies, or conserving your dollars?

Fish And Public Relations

TWO INSTANCES where fishing has been improved by commercial industrial installations have come to our attention recently.

One pictured how offshore drilling for oil in the Gulf of Mexico had in many instances resulted in remarkably good fishing around the platforms upon which the rigs are placed and the crew operates. And the other dealt with how fish seem to like the warm water discharged from an electric company's power plant on the Delaware River. "Excellent catches of wall-eyed pike were made around the plant which is near Martins Creek, Pa.," the news release declared. These reports in themselves are not world-moving, of course. And an area's fishermen aren't the only ones pleased and satisfied at such reports. Thoughtful readers everywhere applaud not only the effect but the causes implied.

The point we would make here is that industry, and particularly HPI plants should never drop their guard in the matter of air and stream pollution. If there ever was an industry that needs to build good public relations, most everyone agrees, it is the oil industry.

Too many people, right or wrong, automatically connect pollution with refineries or other HPI plants. They think the two just must go together. So items that appear in the prints that show this isn't necessarily a fact are most helpful in what should be our continuing effort for improved public relations. Oil companies and plant management should both by design and operating practices do all in their power to keep pollution of atmosphere and our nation's waters to the absolute minimum.

Most important!

COMPUTER ANALYSIS SHOWS TEL ROAD BONUS, TOO

ROAD ON = a + b (R) + c (M) + d (O) + e (TEL)

CONTINUING study and analysis of modern fuel performance requires periodic updating of the familiar road octane prediction equations to maintain the best accuracy. It is now clear that a TEL factor must be added to the usual Research, Motor and hydrocarbon terms in order to predict a Road octane number that closely approximates the real thing.

In fact, results of recent tests indicate that the TEL coefficient can be the single most important compositional factor in computing a fuel's Road octane number accurately.

Here's the Equation

In its present form, the equation includes all four factors affecting road performance.

$$RON = a + b(R) + c(M) + d(O) + e(T)$$

where R = Research octane number
M = Motor octane number
O = Olefins in percent by volume
T = Milliliters of tetraethyllead/gal.

In other words, if two fuels have the same Research and Motor octane number and the same olefin content, the one higher in TEL has the higher Road octane number.

Compare the Coefficients

Recently Ethyl rated the road performance of 32 full-boiling, commercial premium gasolines in four cars. This is how the equation worked out:

$$\text{Road octane number} = 25.70 + 0.353(R) + 0.391(M) - 0.089(0) + 0.466(T)$$

In this series of tests, the TEL coefficient ranged from 0.354 to 0.484, depending on engine speed.

The TEL Road Bonus

If the TEL coefficient is 0.4, then increasing the TEL concentration from 2.0 to 4.0 ml/gal. gives a road bonus of 0.8 octane numbers [(0.4 x 4) − (0.4 x 2)]. This Road octane increase is a bonus over and above the increase in Research and Motor octanes due to added TEL.

In some cases the road bonus from TEL can amount to more than one whole octane number per milliliter of added TEL.

REMINDERS TO REFINERS

Antiknocks are your best octane improvement buy, whether costs are figured on Research, Motor or Road ratings.

Antiknocks give you a Road octane bonus you can't get any other way.

Gasoline sensitivity can be decreased with antiknocks.

Refining flexibility can be increased with antiknocks.

Antiknocks also can reduce or delay capital investment in octane improvement equipment.

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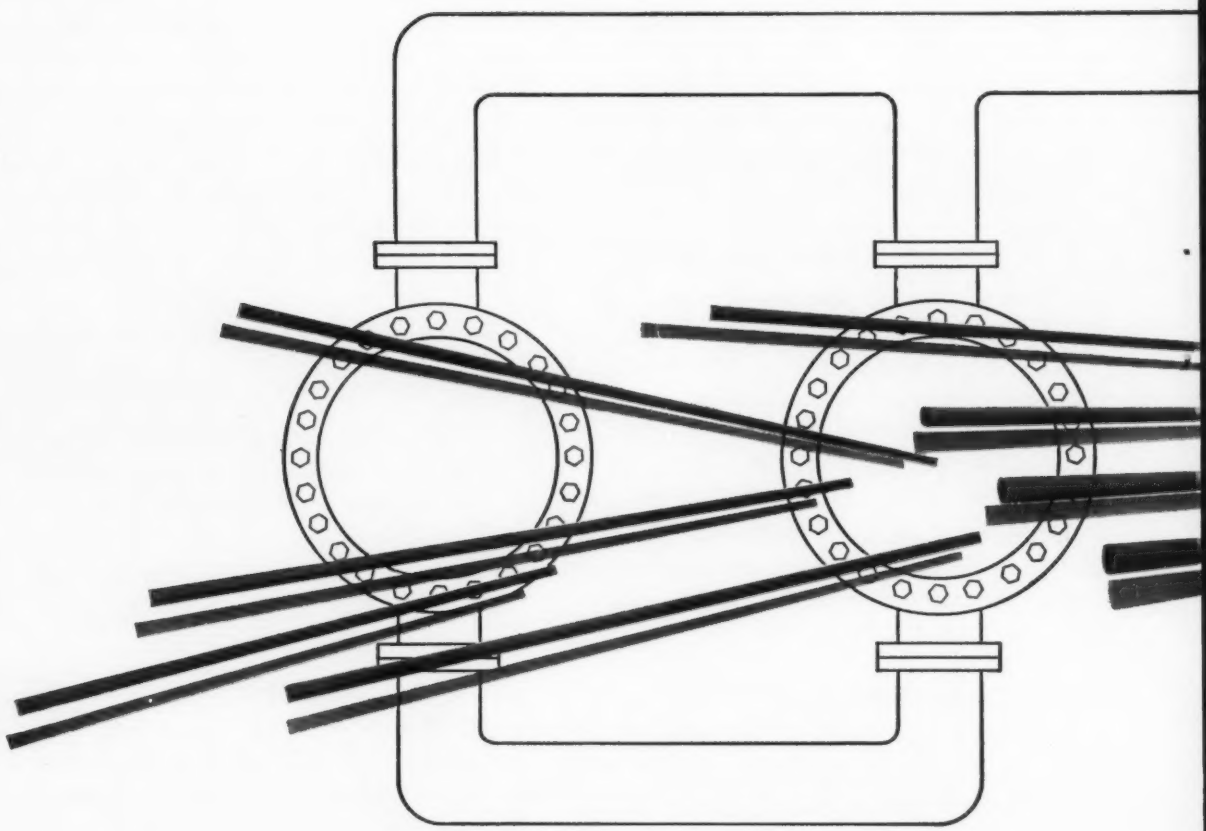

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Wide line of finest quality copper-base alloys for every kind of application need—including bi-metal combinations.

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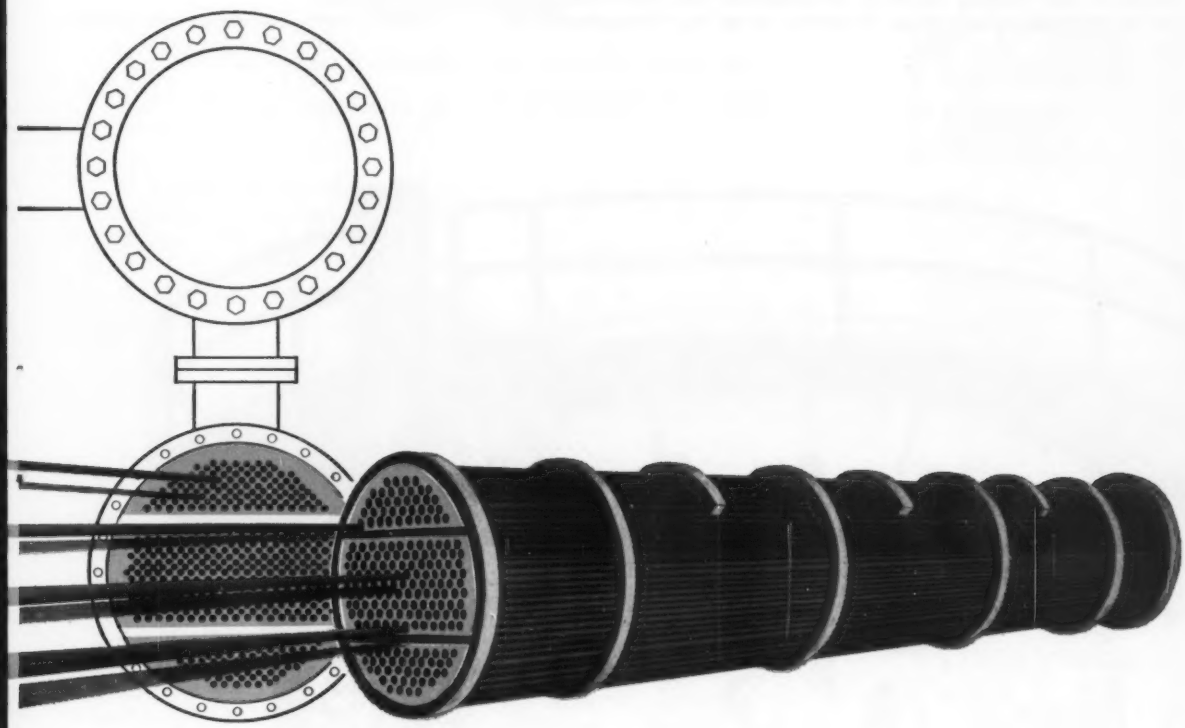

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For more data on advertised products, use Readers' Service Cards, last page.

Gas reforming hits a new high Engineering news was made in France recently, when a Chemico high-pressure gas reform furnace operating at 250 psi was placed on stream. Prior to the completion of this project, no gas reformer in the world had ever operated at pressures above 175 psi. Design innovations incorporated in this plant reduce compression requirements and increase heat recovery.

This historic breakthrough in gas reforming is indicative of the skill and experience which Chemico brings to all process engineering problems. Chemico services to clients in the process industries range from initial laboratory research and testing to final construction and start-up. If you are interested in learning more about Chemico, write to "Department B".

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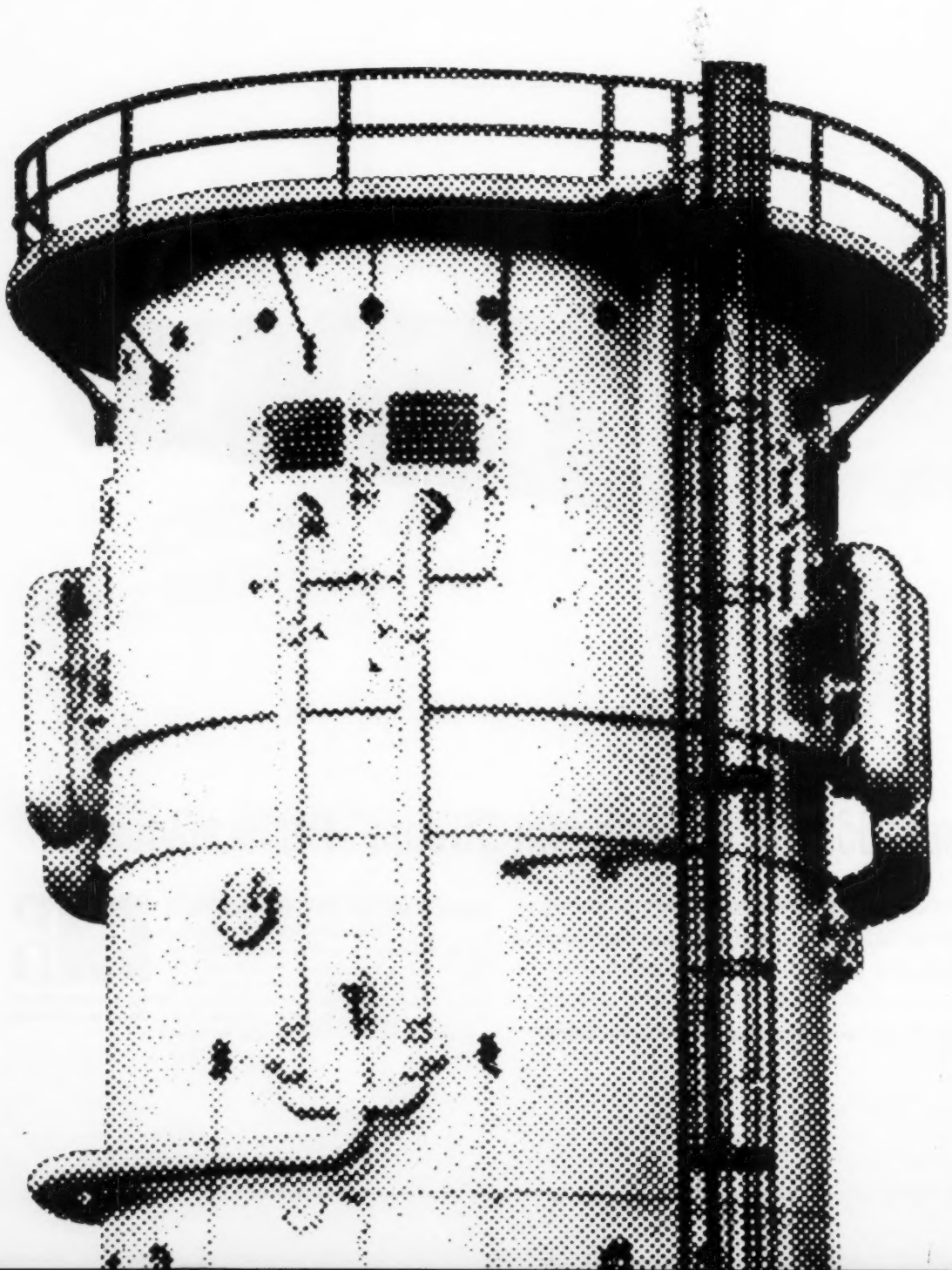


INDUSTRY IQ QUIZ

Test your industrial IQ with this quiz on the current issue of PETROLEUM REFINER

1. Propylene. When was the first chemical polypropylene produced. (a) 1937, (b) 1957, or (c) 1958?

2. Storage Tanks. How much should an atmospheric, vertical, Type 304 SS storage tank of 3,000 gallons capacity cost per gallon. (a) $3.00 (b) $1.95, or (c) $1.45?

3. Control Characteristics. To measure transient response characteristics of any control loop, you need a pulse generator and some means of varying the pulse frequency. True or False?

4. Japanese Petrochemicals. In which of the following petrochemical areas has Japan's organic chemical industry been a major force in world markets? (a) polyvinyl chloride, (b) fertilizers, (c) polyethylene, (d) synthetic fibers.

5. Chlorinated Hydrocarbons. which of the following chlorinated hydrocarbons is showing a definite trend in production rate? (a) vinyl chloride, (b) ethyl chloride, or (c) trichloroethylene.

6. Equilibrium Constants. $\triangle H^\circ$ must be assumed to be constant in order to integrate the van't Hoff equation. True or False?

7. Project Evaluation. The profitability index can be taken as the sole criterion of profitability when evaluating a project. True or False?

8. Cable Costs. Interlocked cable costs in Class 1, Group D, Division 2 areas would compare with conduit and wire in which of the following percentages? (a) 15 percent more, (b) 15 percent less, (c) 25 percent more, (d) 25 percent less, (e) about the same.

9. Floating Roof Tanks. There are three main types of floating roof storage tanks in use today. Which one of the following types is not used? (a) pan type, (b) spoon type, (c) pontoon type, or (d) double deck type.

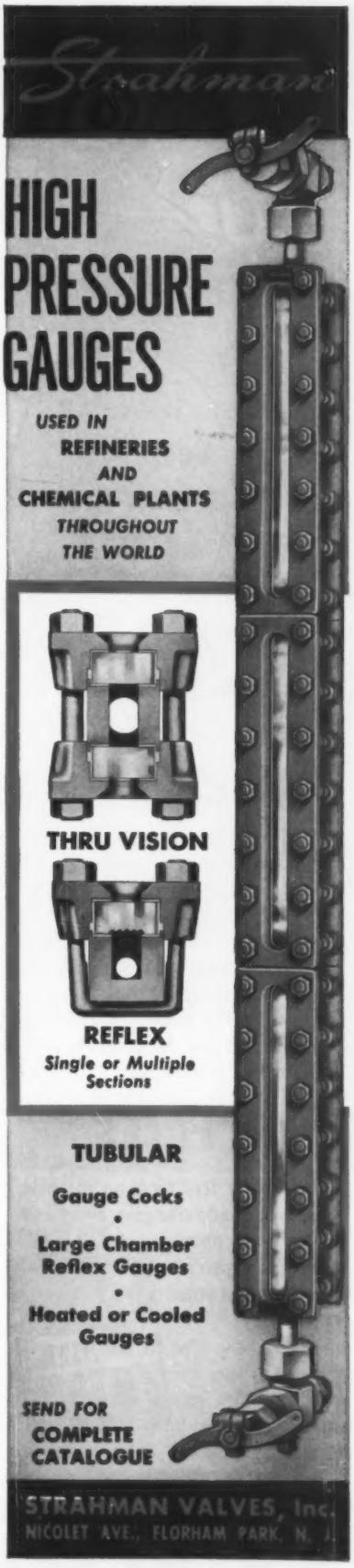
10. Computer Calculations. The time spent to analyze, code and check out a computer program for designing relief valves can be paid out in which one of the following ways? (a) 10 valve sizings, (b) 60 valve sizings, (c) 100 valve sizings, or (d) 600 valve sizings.

11. Product Analysis. Must one product sample be tested over and over to determine the precision of an analysis made in your laboratory?

12. Helium. The newest Bureau of Mines helium plant at Keyes, Okla., produces helium at what cost. (a) $9 to $10 per Mcf, (b) 90 cents to $1 per Mcf, or (c) 40 to 50 cents per Mcf.

13. Viscosity. Of all the physical properties of liquid petroleum fractions, the thermal conductivity is the most affected by an increase in pressure. True or False?

Answers on next page



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Industry Quiz

Answers to questions on page 21

1. (b). It was first produced in 1957 by Montecatini at the Farrara, Italy plant. There is much more to learn about this newest olefin monomer than when it was first produced. And, you can learn it now by reading "How to Make Polypropylene," beginning on page 129.

2. (b) A 3,000-gallon storage tank would cost about $1.95 per gallon. A good rule of thumb is $2.00 to $1.45 per gallon for capacities above 2,000 gallons, and up to 10,000 gallons. You can build a good estimating file by clipping the "Equipment Cost Data File" series, which begins on page 143.

3. False. There is a simple way to measure most of the transient response characteristics of a system. To learn how it's done, don't miss "Analyze Plant Control by Transient Response," on page 145.

4. (a) and (b). Polyvinyl chloride and fertilizers are the only petrochemicals competing in world trade. You'll be interested in Japan's position in other petrochemicals, so check "Watch Japan's Petrochemical Growth," page 149.

5. (b) Ethyl chloride is showing a definite down trend because of its close tie with tetraethyl-lead fluid. However, trichloroethylene (c) shows some down trend problems because of imports. For the complete story on these and other products, be sure to read "Still Growing Fast . . . Chlorinated Hydrocarbons," starting on page 155.

6. True. This assumption is rigorous for reactions between ideal gases where there is no change in moles. You will find this assumption Sufficiently accurate for most real reactions where there is a change in moles. To learn more, don't miss "Find Equilibrium Constants Graphically," on page 163.

7. False. However, profitability index is one of the best measures of project success. But several economic criteria are better than one. For more data on project evaluation techniques, see "How to Evaluate Chemical Projects" on page 171.

8. (b) For a recent installation in Atlantic's new wax plant, cable costs were 15 percent lower than conduit and wire. Furthermore, the cost of the entire cable tray system was almost absorbed in cable cost savings alone. To learn more about this interesting cost study, read "Why Atlantic Used Armor Cable in Division T Areas," on page 177.

9. (b) Spoon may rhyme with pontoon, but there is no such type of floating roof. Three decisions you must make before selecting one of the three main floating-roof types is covered in the opening paragraph of "Choose the Right Floating Roof Tank," on page 185.

10. (b) Phillips Petroleum discovered that relief valve sizing by computer could be paid out in only 60 valve sizings. For the hows and whys, be sure to see "Use Computers to Size Relief Valves," on page 193.

11. No. Although this is one way to see how well your lab is doing, there is another way described in "How Well Can You Rely on Lab Tests," beginning on page 201.

12. (a) The exact figure is $9.11 per Mcf, according to the latest government report. Plant operating data as well as unit cost data are broken down for the first nine months of operation at the Keyes, Okla., plant in "How Newest Helium Plant is Working," on page 205.

13. False. Although the thermal conductivity is significantly affected, it is viscosity which is most affected by increasing pressures. For a given petroleum fraction at room temperature and 6,000 psia. (as compared with atmospheric pressure) it has increased properties as follows: density, 2 percent; heat capacity 2 percent; thermal conductivity 8 percent; and viscosity, 50 to 100 percent. For the whole story, see "Liquid viscosities at High Pressure," page 209.

Photographed at DX Sunray, (Tulsa Refinery)

For higher yield... new Aerocat 3C

CAN YOU USE a higher yield of gasoline—? or of propylenes or butylenes—? Then investigate the new AEROCAT 3C! It's a new fluid cracking catalyst composition, developed by Cyanamid in cooperation with a major oil company. AEROCAT 3C-12 gives increased gasoline yield . . . AEROCAT 3C-20, increased propylene and butylene yields . . . both at the expense of dry gas and coke.

In actual commercial operations, these new three-component catalysts have proved their ability to provide refiners with more flexible, more profitable operation. They are highly active, exceedingly stable, and completely operative.

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Basic in catalyst chemistry

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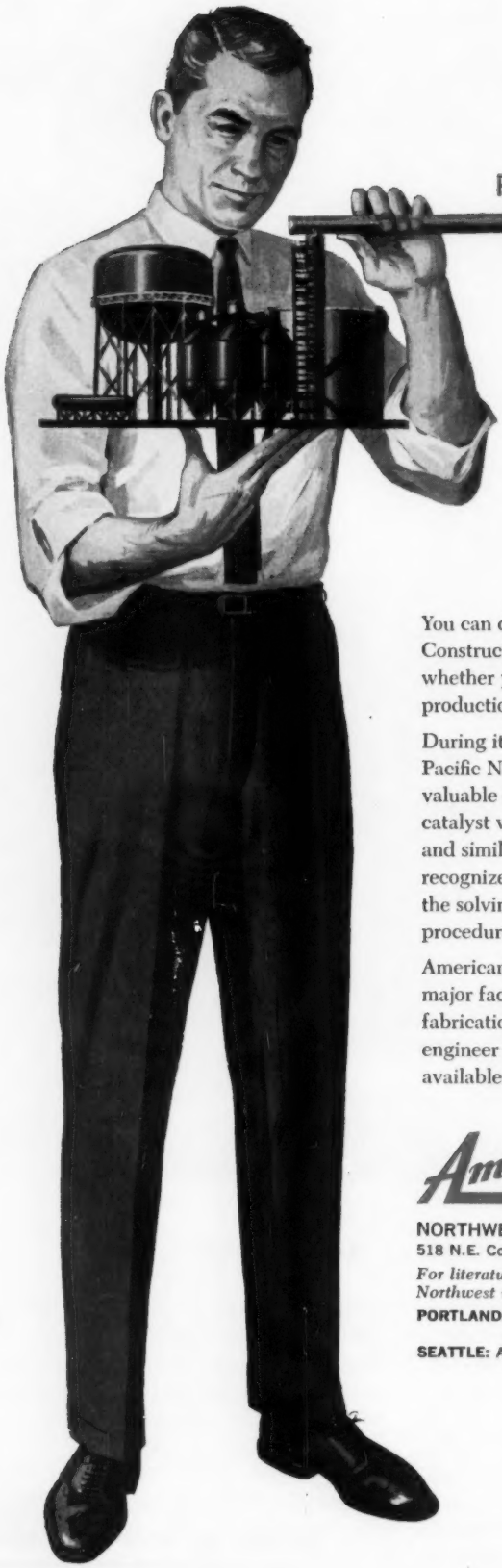

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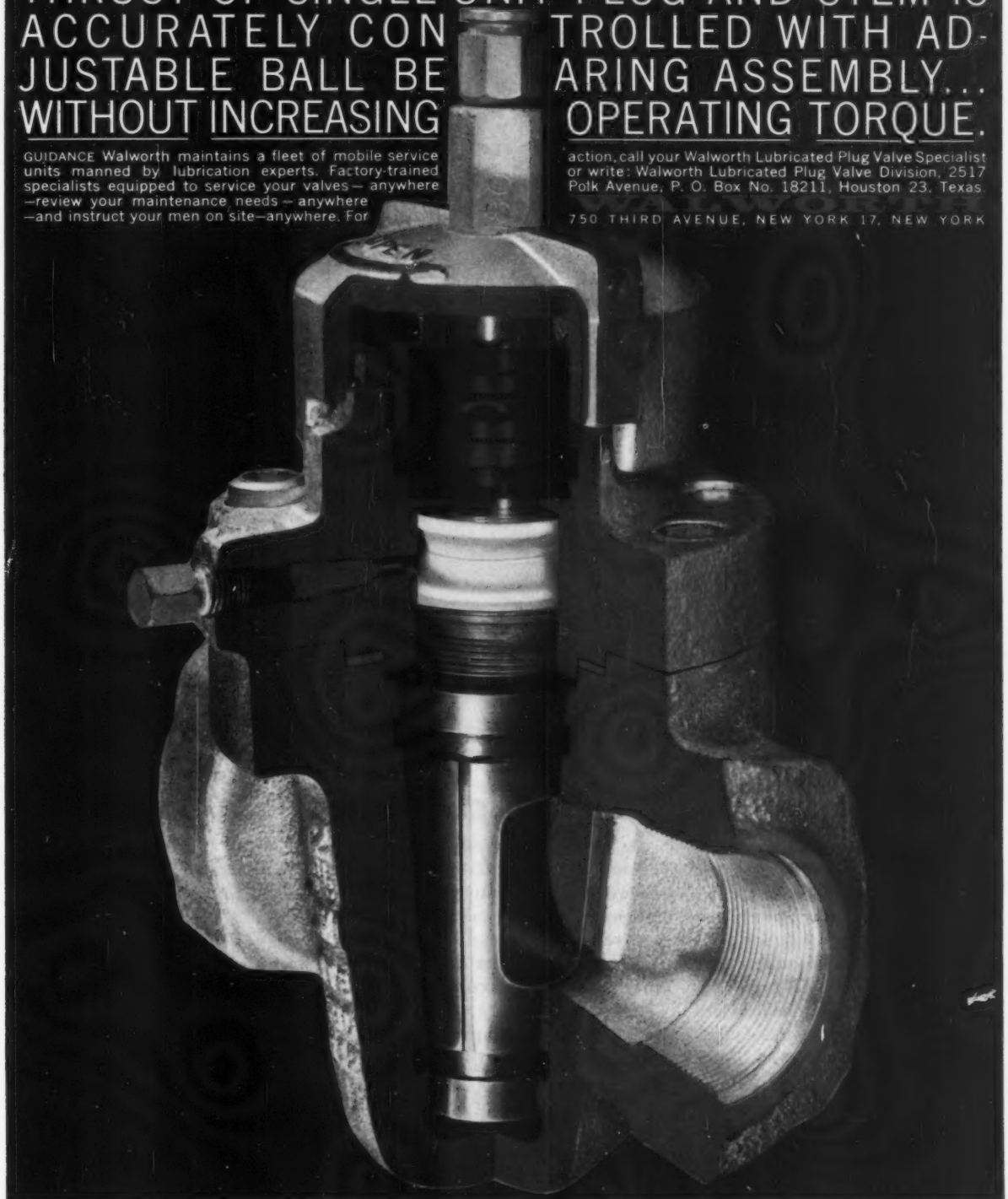

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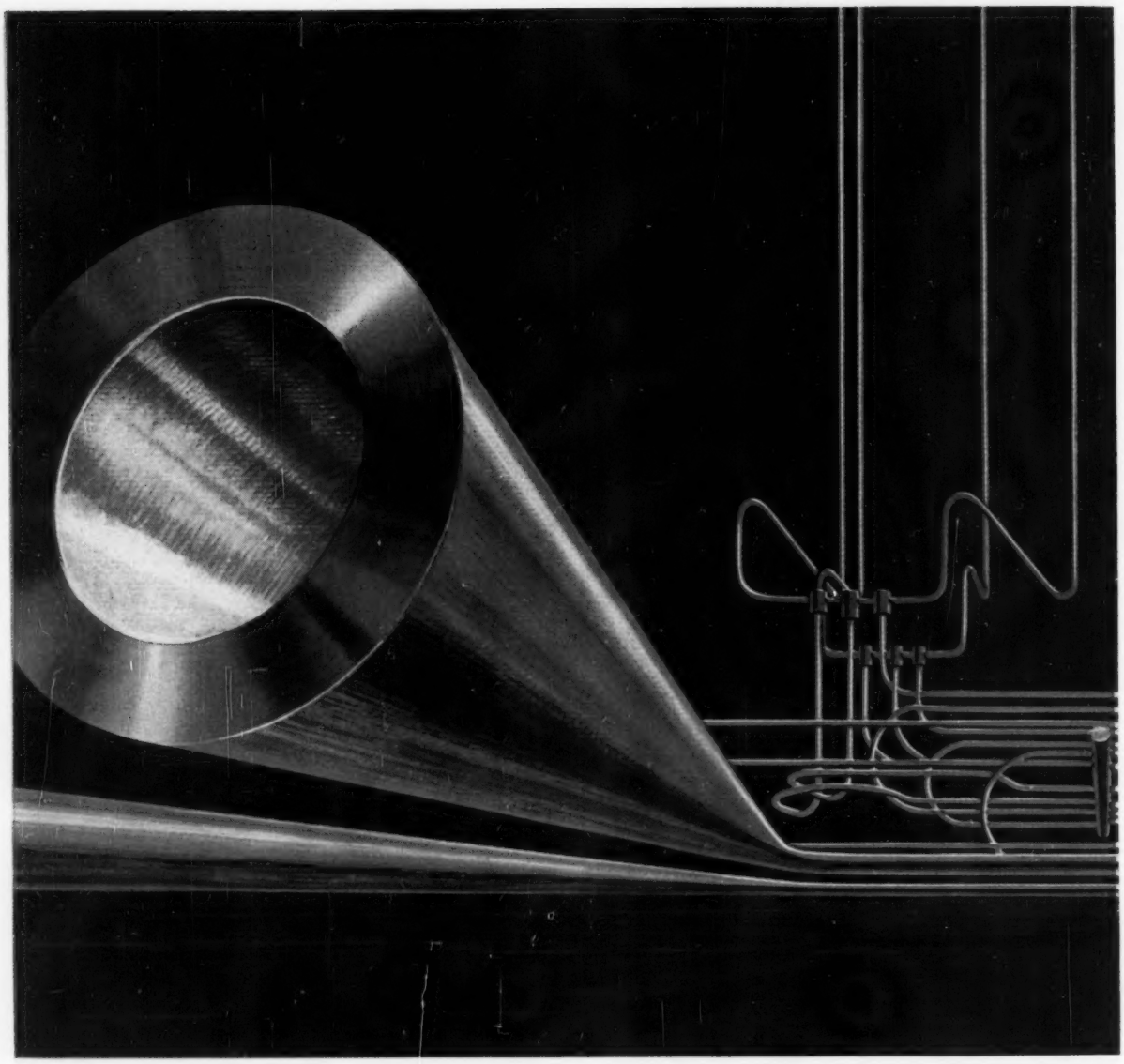

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HOKE Flow Sheet 4

HOKE REPORTS ON FLUID CONTROL

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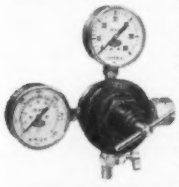
One trouble with doing something better is that it's hard to stop. This time, we've come up with a new line of pressure regulators. We made them for the technically oriented who have developed high standards and for the penurious purchaser who wants something for (almost) nothing.



One, tagged as the 680 Series, is a highly stable single stage regulator with something for just about everyone. The core of this regulator is its control accuracy of 2% at flows to 2000 SCFH. Two models are available. One delivers 0 to 40 psi and the other 0 to 140 psi and both can handle inlet pressures up to 3000 psi. Use them on any gas compatible with 2024-T4 aluminum alloy, neoprene, polyurethane and Buna-N.

If what we've said sounds good so far, but still won't solve your problems, read on.

We've built a regulator specially for corrosive gases and atmospheres. Available in either all monel or all stainless steel construction, we call it the 640 Series. Spec sheets on this can be had by marking an "X" below.

If you "X" the next box, you'll get a package of useful information on a special regulator that will handle delivery pressures up to 4500 psi with very high control accuracy. This is a 2 stage spring and dome loaded regulator and we claim that a 50% change in inlet pressure will not change the delivery pressure more than 2%. Operation is simplicity itself. For no particular reason, we call this the 920 Series.

Skeptics should send for all of this information.

For reasons now hidden by the veil of tradition, no one has ever attempted to scrunch a pressure switch to its proper proportions—that is, until now. With sales getting bigger from making things smaller, we decided that this was the path to profit. Ergo; the new Hoke Pamar pressure switch.

This isn't just a case of arrested development, but something entirely new. The scrunching process necessitated less parts, so conventional connecting linkages were the first to go. The direct result: a switch with only one moving part—nothing to wear and upset the actuation setting.

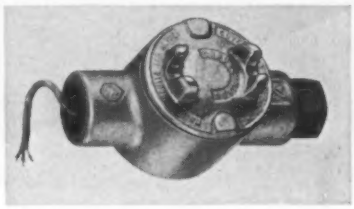
The ordinary bellows was out of the question, so we used a Ni Span C capsular type sensing element. Out of this came such things as high repeatability, minimum hysteresis and drift, maximum temperature stability, and a dead-band of minor significance.

The whole assembly measures less than 2 inches from tip to terminals, and weighs short of one ounce. Despite these diminutive dimensions, it is capable of handling working pressures to 500 psi with a repeatable accuracy of ±0.5%. Electrically, it sports a snap-action switch that will conduct a current of up to 7 amps to a variety of connectors – AN, cabled leads, solder terminals, or whatever you want. Interested in pressure switches for explosive atmospheres? Specify the explosion-proof model.

A special low pressure switch (0 to 7 psi) defies competition with a dead band of 2" of water!

If what you're looking for in a pressure switch seems impossible to find (even with the wonders we've described here), we'd like to hear about it. We thrive on doing what others shrink from, and will build a switch to your specs. Write and tell us your problem.

We could go on, but that wouldn't leave us with the usual advertising "hooker". We want to hear from you. In return, we'll send you the rest of the story.



WHAT'S NEW FROM HOKE?

Lots of things have been happening at Hoke. To be sure you're up to date on these developments in fluid control see your nearest distributor. He'll have something new for you every other month this year.

Hoke's Performance Guarantee—*Every Valve Leak-Tested!*

HOKE INCORPORATED
167 Piermont Road, Cresskill, N. J.

Send me complete information on the Hoke products checked below:

- ☐ Pamar Pressure Switches
- ☐ 680 Series Regulator
- ☐ 640 Series Regulator
- ☐ 920 Series Regulator
- ☐ "What's New"

NAME _____ TITLE _____

COMPANY _____

ADDRESS _____

CITY _____ STATE _____

SEE OUR CATALOG IN SWEETS PRODUCT DESIGN FILE

For more data on advertised products, use Readers' Service Cards, last page.

CALL YOUR MIDWEST DISTRIBUTOR

Midwest stocks chrome-moly fittings in all standard types, sizes and wall thicknesses—cutting costly downtime to a minimum.

And, if the fitting you need is *not* standard, it can be produced quickly from the full stocks of raw materials maintained by Midwest.

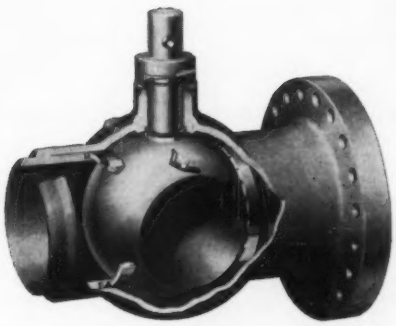
When you need replacement fittings, get back on stream fast! Call your Midwest distributor for quick, dependable delivery and service.

MIDWEST PIPING CO. INC.
1450 S. SECOND ST., ST. LOUIS 4, MO.

6109

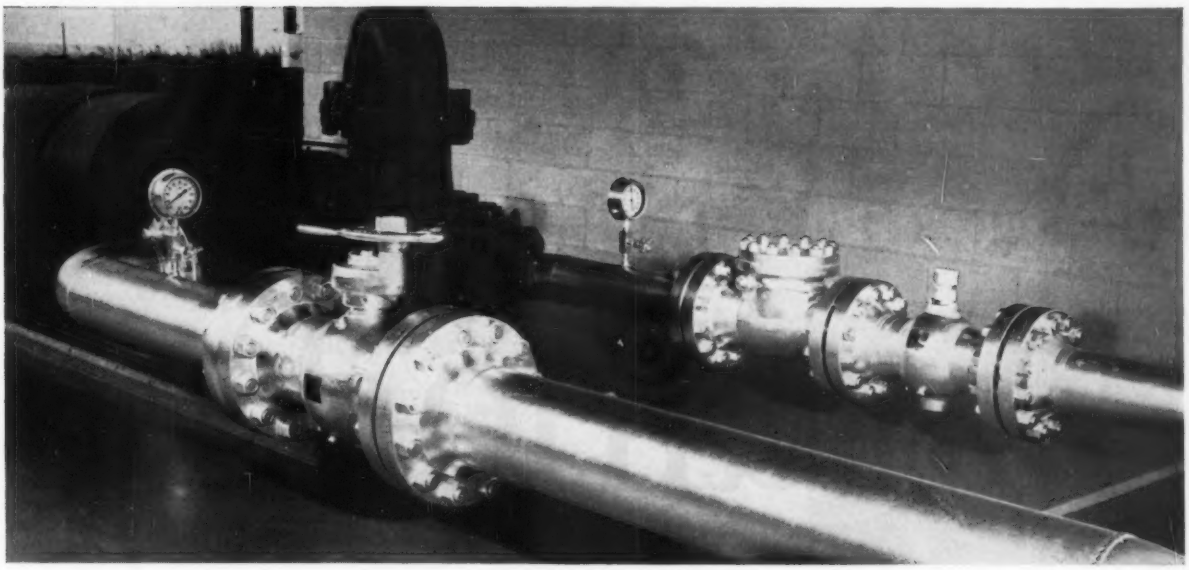
For more data on advertised products, use Readers' Service Cards, last page.

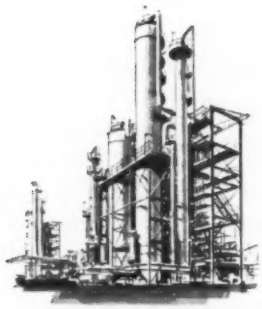
SAY GOODBYE TO VALVE REPAIR



That's right – with Cameron Ball Valves on the job you never need to make repairs. This big step forward in valve design – which makes practical the "sealed for life" construction – is brought about by the exclusive rotating seat principle which has proven so successful in our Type "F" Gate Valves.

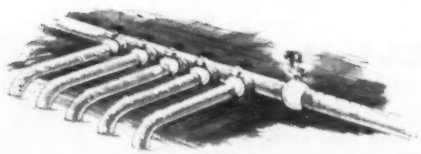
Sturdy dogs on the Ball engage gear-like teeth on the Seat Rings to rotate the Seats a fraction of a turn each time the valve is opened. In all valves, maximum wear occurs on the seating surface area which is struck by the erosive blast of line fluid just as the port is uncovered on opening, or just as the flow is being pinched off on closing.





Rotation of the seats distributes this wear equally over the entire sealing surface and extends the life of the valve many times over valves with stationary sealing surfaces.

Also, being non-lubricated, all maintenance costs are eliminated. This means substantial savings in man hours, down time and inventories. Low torque requirements allow smaller operators – less energy on remote controls – easier operation an manual controls. Maximum economy – Maximum service – Mimimum size and weight. Available in sizes 2″ to 36″ in ASA and API ratings and with any type of end preparation. If you plan, specify or purchase valves, call or write Cameron for complete details.



Cameron

CAMERON IRON WORKS, INC. • P. O. BOX 1212 • HOUSTON, TEXAS

For more data on advertised products, use Readers' Service Cards, last page.

accuracy

ASHCROFT DURAGAUGES measure pressure with precise accuracy no matter how severe the conditions of service

Ashcroft Duragauges are available in pressure ranges from 15 psi (or vacuum) minimum to 100,000 psi. Dial sizes: 4½" through 12".

sustained

The Bourdon tube in Ashcroft Duragauges is manufactured to precision standards of flexibility and mono-linked to the rotary movement. When pressure flexes the tube, the gauge pointer is always positively positioned, because it is mounted on the geared center shaft of the movement. Sustained high accuracy and long life are assured.

Choose your Ashcroft Duragauges made of components best suited to your needs. Eight Bourdon tube materials are available. Movement of stainless steel with nylon bearings and pinion gear for longest wear. Case materials: special aluminum alloy or tough phenol plastic.

The unique "Maxisafe®" Duragauge provides absolute protection to the viewer, plus easy and quick access to the mechanism. Your industrial supply distributor will help you select the best combination of components for your Ashcroft Gauge requirements. Phone him today or write for Catalog 300B.

MAXWELL MANNING M&M & MOORE INC. TRADE MARK

ASHCROFT PRESSURE GAUGES

A product of

MANNING, MAXWELL & MOORE, INC.

Gauge and Instrument Division • Stratford, Connecticut

Canada: Manning, Maxwell & Moore of Canada, Ltd., Galt, Ontario
Latin America: Export Division, Chrysler Building, New York, N. Y.
Europe: Manning, Maxwell & Moore, S. A., Fribourg, Switzerland

For more data on advertised products, use Readers' Service Cards, last page.

Quality control is a relentless task at J&L. Here a skilled metallographer examines steel structure through a modern photomicroscope.

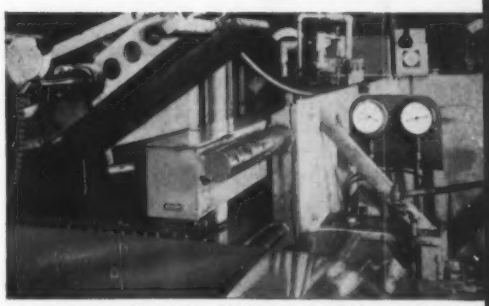
Be 100% Certain...Buy 100% Tested Pressure Tubing

J&L Electricweld pressure tubing is the finest carbon steel tubing available for heat exchanger, condenser, boiler, evaporator and other applications—yet shows savings of as much as 45% against seamless tubing.

J&L Electricweld pressure tubing provides the uniform outside diameter, wall thickness and concentricity that guarantee excellent heat transfer characteristics and fine surface quality. Its strength and ductility assure easy fabrication and installation.

J&L Electricweld pressure tubing is subjected to precise checks at every stage of production, from the basic steelmaking process until the tube is ready for shipment. This series of critical examinations on every length of tubing—inside and out—assure you of perfect field performance. Further details of Electricweld tubing and the economies it offers compared with seamless are available on request from J&L—creator and producer of *unmatched* Electricweld tubing.

J&L uses this latest type of electro-magnetic nondestructive tester to inspect both the inside and outside of Electricweld pressure tubing.



Dimensional accuracy of J&L Electricweld pressure tubing is determined long before fabrication. Shown here is an X-ray gauge control device which continuously measures the gauge of the sheet and strip steel.

This Steelmark identifies products made of steel. Place this mark on your products. And—look for it when you buy.

Steel

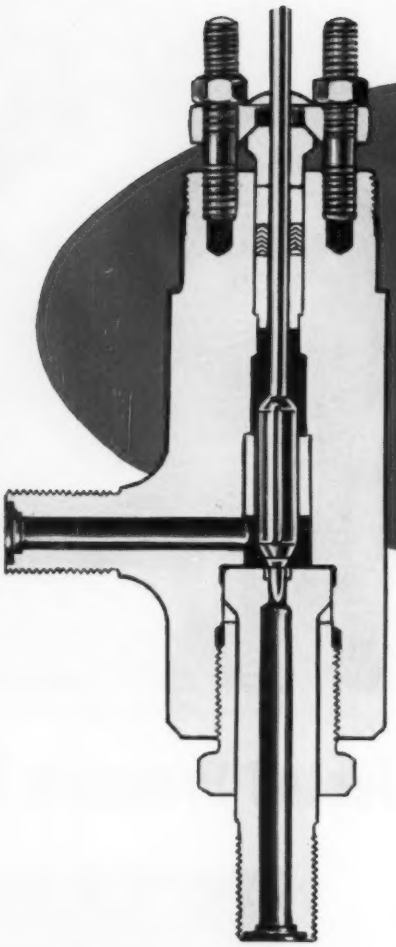
J&L STEEL

Jones & Laughlin Steel Corporation

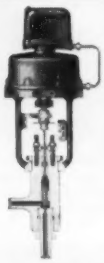
ELECTRICWELD TUBE DIVISION • 3 GATEWAY CENTER, PITTSBURGH 30, PA.

see FISHER for your

Ultra High Pressure Jobs

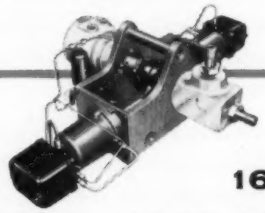


When you encounter pressures up to 60,000 psi at 500°F., Fisher can help by designing and producing a high pressure control valve for your specific need ● Typical is the Design "C" Body, a hammer forged unit for pressures ranging from 5,000 to 35,000 psi ● When required, body forging is heat treated and hardened for added structural strength ● Can be produced in Monel, stainless steel, Titanium, and other alloys. Available in a wide variety of high pressure end connections.



470-C

TYPE 470-C utilizes the popular 470 P.O.P. mounted on the hammer forged "C" body. Has received wide acceptance in processing of ammonia and urea. Handles pressures up to 45,000 psi.



16531

TYPE 16531 is a specially designed high pressure control valve for polyethylene let down service. Hammer forged body activated by two powerful 480 P.O.P. actuators which can take independent signals for automatic operation or from manual loading station. Either electrical or pneumatic valve position transmitter.

For complete information on Fisher high pressure control valves send for Bulletin E-500-A.

Fisher Governor Company, Marshalltown, Iowa. Plants in Woodstock, Ont., Rochester, England. Butterfly Valve Division: Continental Equipment Co., Coraopolis, Pa.

If it flows through pipe anywhere in the world ...chances are it's controlled by.....

FISHER® Controls SINCE 1880

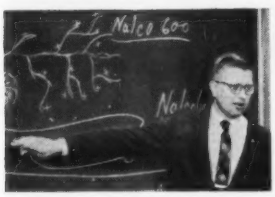
A Nalco PRODUCT MANAGER

Discusses Nalco 600 Coagulant Uses, Economies and Characteristics

Cationic Polyelectrolyte Liquid is Non-Corrosive, Unaffected by Variable pH or Contaminants

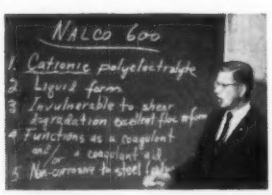
Nalco 600, unlike most coagulants and coagulant aids, can be mixed thoroughly to insure full contact with turbidity particles without danger of shear degradation—the breaking up of coagulant molecules caused by agitation such as pumping, mixing and aeration. Thorough agitation actually improves Nalco 600 action in forming heavy, fast-settling floc!

"Nalco 600 is a branched polymer which is very effective in forming extremely heavy floc," reports J. T. Burke, Manager, Nalco Coagulation Chemicals Department.



". . . 600 is both a coagulant and a coagulant aid . . ."

Because of its cationic character, Nalco 600 is both a coagulant and a coagulant aid. It can be used alone to form floc, or it can be used with alum or sodium aluminate to bridge already-formed floc particles and give them added size and weight to speed settling. Whether Nalco 600 is used as a coagulant or as a coagulant aid depends on the water being treated, throughput rates, and many other conditions that your Nalco Representative can help you analyze to be sure of obtaining the best type of coagulant treatment for your particular requirements.

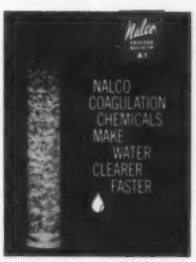

NALCO 600
1. Cationic polyelectrolyte
2. Liquid form
3. Invulnerable to shear degradation excellent floc form
4. Functions as a coagulant and/or a coagulant aid
5. Non-corrosive to steel tanks

". . . a non-corrosive, liquid coagulant . . . has many advantages . . ."

Dosage, feeding and handling of Nalco 600 are greatly simplified because of its liquid form—the *only* cationic polyelectrolyte coagulant chemical available as a liquid. Added to convenience of handling are 600's non-corrosive characteristics. Stable Nalco 600 can be stored in drums or ordinary steel tanks without worry about corrosion damage. Steel feeding equipment and piping are safe, too.

". . . pH fluctuations and organic contaminants do not impair 600 performance."

Most coagulation troubles in water systems are caused by organic contaminants entering the systems in varying amounts and upsetting the coagulation chemical dosage rates. This is another area of trouble-free operation with Nalco 600. It is not affected as much by organic contamination as other coagulant chemicals are—and it stays effective through wide pH fluctuations . . . unlike alum, where a delicate pH balance must be maintained to get proper flocculation and settling.



". . . no substitutes for effective chemicals, programmed by experts . . ."

Your Nalco Representative has both the chemicals and the skills to be genuinely helpful to you in getting coagulation results that maintain high clarification rates with sensible treatment economy. His application experience with the wide range of Nalco water treating chemicals is one of the important reasons Nalco has been able to take coagulation and clarification problems out of the realm of guesswork and put them on a sound, practical basis.

Call today for action from your Nalco Representative, or write for Nalco Process Bulletin A-1 for detailed information on Nalco coagulant chemistry.

NALCO CHEMICAL COMPANY

6259 West 66th Place • Chicago 38, Illinois

Subsidiaries in England, Italy, Mexico, Spain, Venezuela and West Germany
In Canada: Alchem Limited, Burlington, Ontario

Nalco® . . . Serving Industry through Practical Applied Science

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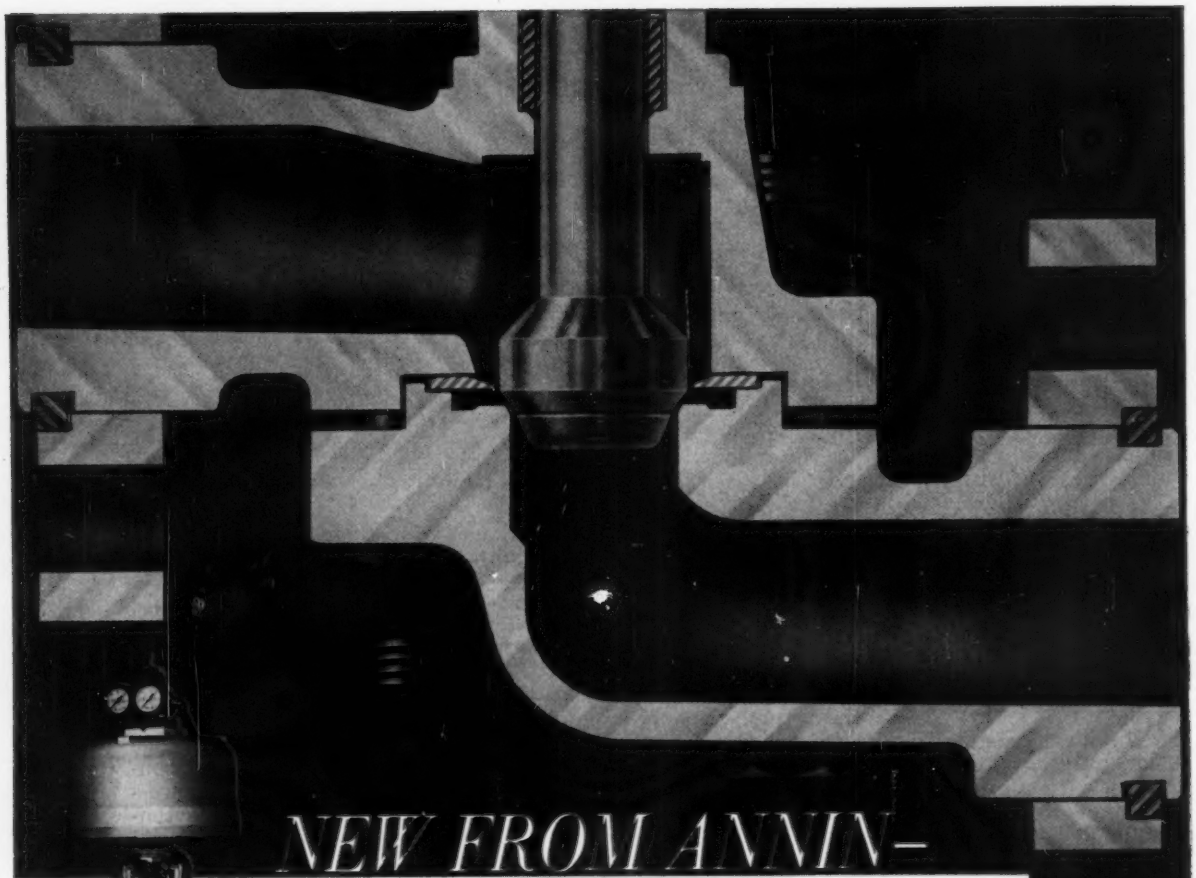
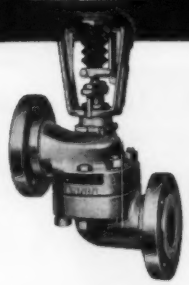


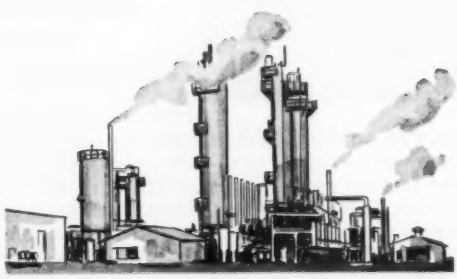
NEW FROM ANNIN—

The Control Valve that Drains Itself



ANNIN'S MODEL 1900 SELF-DRAINING CONTROL VALVE is designed to completely drain the line and valve body of corrosive fluids, slurries, and other flowing media which contaminate or tend to set up and harden in the system. Body and trim are designed so that all surfaces slope downstream, making the valve completely self-draining when installed in either the horizontal or vertical position. All body parts are interchangeable with other Annin models, allowing an option of globe, angle or three-way body patterns. Model 1900 is designed to accept all standard actuators—Pneumatic Domotor, Electro-Pneumatic, Electro-Hydraulic, Cylinder or Manual.

Send for latest technical information.



Model 1900 has many applications in the process industries, both in batch operations which require cleansing of the system after each run and in continuous processes after the system is shut down. Unique self-draining design of the valve body eliminates problems of fluid contamination, fermentation, toxicity and solidification.

Annin **VALVES**

THE ANNIN COMPANY
1040 South Vail Avenue,
Montebello, California

For more data on advertised products, use Readers' Service Cards, last page.

DU PONT *Petroleum Chemicals* NEWS

Number 107 in a series of bulletins for the Petroleum Industry

MARCH • APRIL 1961

TETRAMIX* offers new flexibility in choice and use of lead antiknocks

In the few brief months since the introduction of Du Pont TETRAMIX antiknock compound, refiners have found that it offers a new degree of flexibility in their choice and use of lead antiknocks. For example, while its effectiveness varies with gasoline composition (as is true with other antiknocks as well), TETRAMIX is generally effective in low, medium and high dosages.

Results of tests to date indicate that TETRAMIX is also a more effective antiknock in some fuels than either tetraethyl or tetramethyl lead —that is, a given octane number can, in such fuels, be obtained with lower concentrations of TETRAMIX than with TEL or TML. Being a mixed lead alkyl, TETRAMIX brings to many gasolines the best qualities of TEL and TML.

Based on this refining flexibility and the potential savings it offers in blending gasolines to desired octane numbers, TETRAMIX antiknock compound has already won refiners' acceptance. With commercial quantities available, now is the time for *you* to investigate the potential advantages of TETRAMIX.

Because you have a choice of lead antiknocks at Du Pont, you'll get impartial help in selecting the best one for *your* gasoline stocks. Your Du Pont Petroleum Chemicals Division representative can assist you in evaluating the relative merits of TEL, TML and TETRAMIX.

*Trademark

Commercial shipments of Du Pont TETRAMIX are now rolling to refiners.

All in the family

TETRAMIX, Du Pont's new lead antiknock compound, is a combination of all possible tetramethyl-ethyl lead compounds. It provides the best qualities of both TEL and TML in a single additive.

Announced in the fall of 1960, TETRAMIX represents the latest in a series of Du Pont petroleum additive developments that dates back to the commercial introduction of TEL in the early 1920's.

Now . . . 4,507 motorists in a nutshell

The "Summary Report" of the Du Pont "Profile of the Motorist" study is soon to be published. This new booklet will give you a nutshell version of the results of the most extensive survey ever made of the driving-and-buying American public.

In handy, concise form, this new publication will contain answers to questions about how people react to price wars, give-aways, trading stamps, regular vs. premium gasolines, TBA

ADVERTISEMENT—Prepared for the Petroleum Chemicals Division of E. I. du Pont de Nemours & Company (Inc.)

OVER

DUPONT *Petroleum Chemicals* NEWS

CONTINUED **4,507 motorists**

purchases, credit cards, vacation driving and daytime TV . . . and many other facts that further define and analyze the motorist and the market he represents.

In the "Profile of the Motorist" study itself, 4,507 motorists were interviewed in marketing areas from coast to coast. The broad findings, trends and many cross-tabulations will be published in the "Summary Report." Comparisons with earlier DuPont surveys are also to be included.

Copies of the "Summary Report" will be available about April 1. For your copy or for information on the study itself, contact your DuPont Petroleum Chemicals representative.

MANAGER
GULF COAST REGION

CHARLES D. TOWERY, Manager of the Gulf Coast regional office for DuPont Petroleum Chemicals, has been associated with DuPont since 1947.

Starting as a sales service representative for the Petroleum Chemicals Division in the Gulf Coast District, he later was manager of the Mid-Continent region before moving to his present position.

Prior to coming with DuPont, Mr. Towery was employed by Bethlehem Supply Company of Houston, the Gulf Oil Corporation and the Pure Oil Company. He also served as a petroleum advisor in the U. S. Bureau of Ships during World War II.

He received a Bachelor of Science degree in Chemical Engineering from Texas A. & M. College in 1932. He and his wife live in Houston with their four children.

The many DuPont services are available to refiners and marketers in the Gulf Coast area through Mr. Towery's office – to aid in the solution of petroleum additive problems.

Color gives fuel oil a new selling advantage

Oil companies know that the subtle differences between competitive petroleum products often can mark a wide variation in their sales value to consumers.

One of these factors in fuel oils, for example, is the very appearance of the product. Consider the relative sales appeal of fuel oil in its normal state versus the same oil after a distinctive color has been added to it. Perhaps the burner is unaware of the difference, but marketers and consumers alike can recognize a difference. Such a distinction may be the sales advantage you seek.

To this end, DuPont petroleum dyes offer you several built-in features: an unlimited choice of colors, color-fastness for lasting value, availability in powdered, flaked or crystalline forms; rapid deliveries; experienced technologists to advise on color selection, application and use.

Your DuPont representative will gladly offer this advice—or provide you with our latest booklet on DuPont Petroleum Dyes.

"Down the Road" now appearing on America's screens

"Down the Road," the CinemaScope movie sponsored by DuPont to stimulate interest in auto travel, is now appearing in movie theaters across the country.

Narrated by Lowell Thomas, the ten-minute color featurette is an adventure in itself – a thrilling visit by automobile to all corners of America, from the Painted Desert to New England, from the sands of Daytona to the mountains of Canada.

In sponsoring "Down the Road" DuPont is promoting expansion of the demand for petroleum products by encouraging a greater interest in the heritage and beauties of America—and the ease and comfort with which they are available via automobile.

Motorists in *your* marketing area will soon be seeing "Down the Road." If you are interested in tying in with the travel promotion value of this film, your DuPont Petroleum Chemicals representative can give you data on local bookings.

RADIO CITY MUSIC HALL, New York City, was the site of the Eastern premiere of "Down the Road," in mid-January.

SALES OFFICES

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Cleveland 15—101 Prospect Ave. . . . . MAin 1-3422
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Los Angeles 17—612 So. Flower St. . . MAdison 4-1354
New York 20—45 Rockefeller Plaza 212-CO-5-2342
Philadelphia 2—3 Penn Center Plaza . LOcust 8-3531
Pittsburgh 22—1 Gateway Center . . . . ATlantic 1-2933
San Francisco 4—111 Sutter St. . . . . EXbrook 2-1934
Seattle 3—4003 Aurora Ave. . . . . MElrose 2-6977
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In Canada—DuPont of Canada Limited, Petroleum Chemicals, 85 Eglinton Ave. East, **Toronto 12,** Ontario . . . . . HUdson 1-6461
OTHER COUNTRIES: Petroleum Chemicals Division, Export Sales, Wilmington 98, Delaware . . . . . PRospect 4-5009

DU PONT
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Better Things for Better Living
. . . through Chemistry

DuPont Lead Antiknock Compounds and other Petroleum Additives

OVER

ADVERTISEMENT—Prepared for the Petroleum Chemicals Division of E. I. du Pont de Nemours & Company (Inc.)

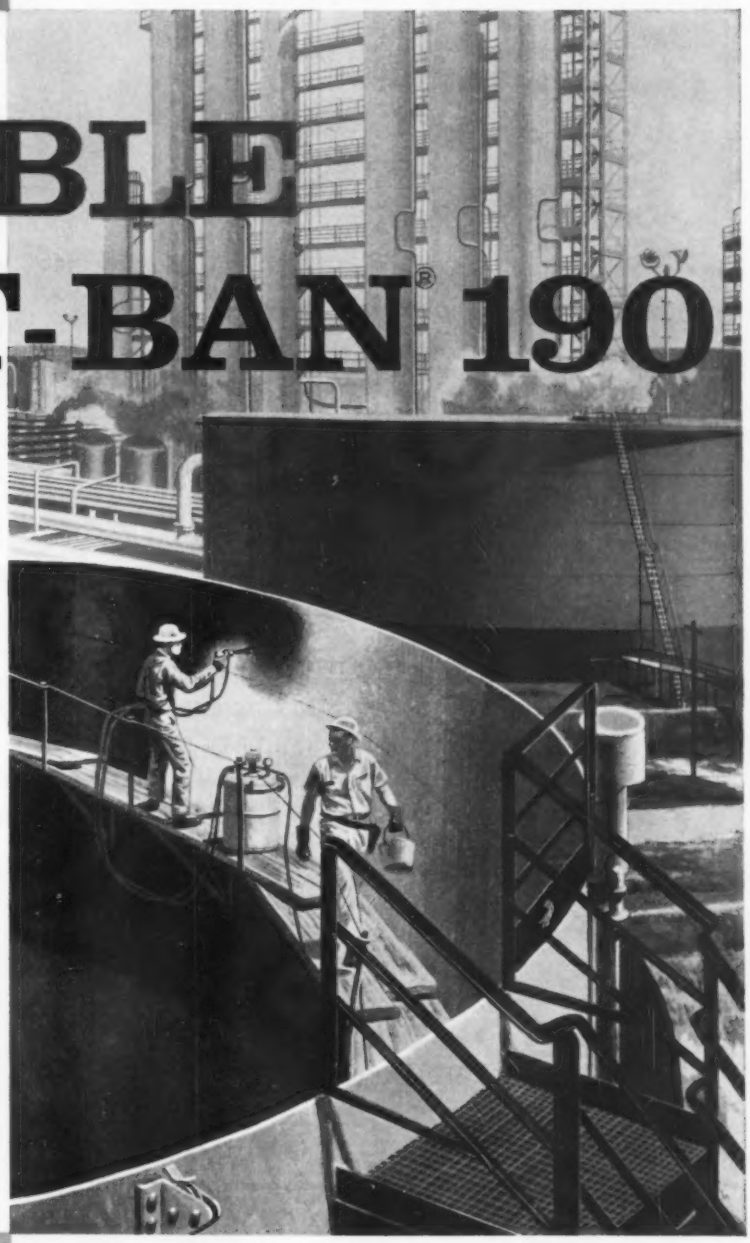
A-19007

Printed in U.S.A.

REACTS WITH THE STEEL...

...eliminates underfilm corrosion in finished product tanks

HUMBLE RUST-BAN® 190



This remarkable new coating bonds so perfectly to steel that you cannot discover an interface! The reason? Humble RUST-BAN 190 reacts *chemically* with the steel. The resulting bond is inseparable . . . completely eliminating underfilm corrosion.

The hard, abrasion-resistant coating of 100% inorganic zinc silicate is virtually impervious to the scraping action of floating roofs. RUST-BAN 190 is nonflammable, does not contaminate even high-purity products.

When properly applied and cured (with its companion RUST-BAN 195) RUST-BAN 190 provides many years of protection at far lower annual cost than any other type of coating!

For complete information about RUST-BAN 190 and other Humble Protective Coatings, call your Humble salesman or contact Humble Oil & Refining Company, Houston, Texas.

HUMBLE

America's Leading ENergy COmpany

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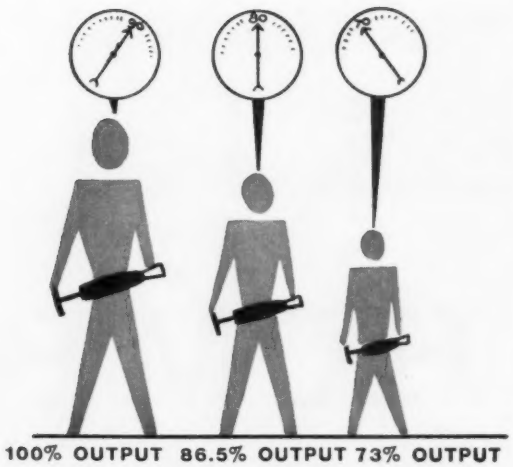
If your tools require a pressure of 90 psi, your production efficiency drops 13½% if pressure falls to 80 psi, and drops 27% if pressure goes down to 70 psig.

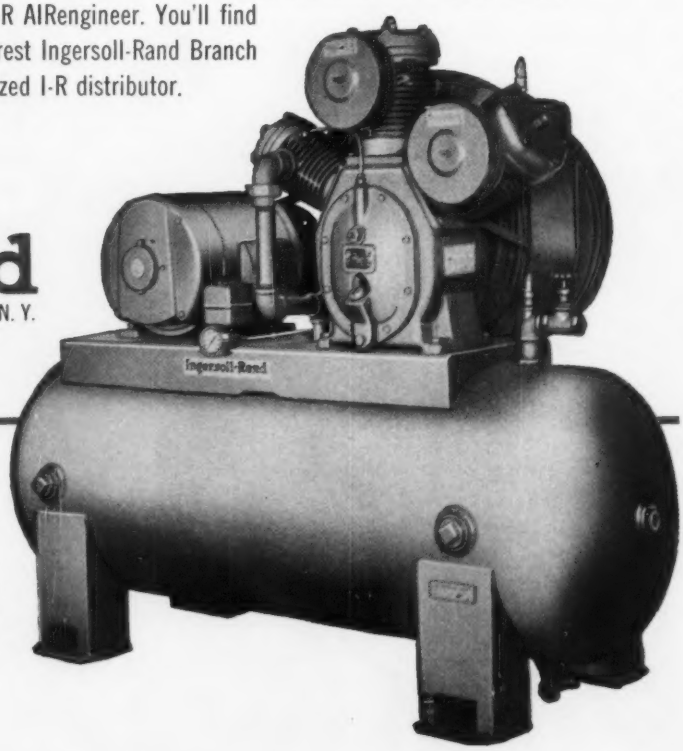


how low air pressure ***shrinks your manpower!***

EXPERIENCED PRODUCTION MEN know that the biggest thief of production with air tools and air operated equipment is low air pressure at the tool when operating under load. This costly condition, which can exist even if air systems are new, requires constant checking to maintain correct pressure at the tools.

LOW TOOL PRESSURE can result from inadequate piping, leakage or an overworked compressor . . . To find out quickly if you are getting full production from your air tools and equipment, ask today for a brief survey by a qualified I-R AIRengineer. You'll find one at your nearest Ingersoll-Rand Branch Office or authorized I-R distributor.

Ingersoll-Rand
11 Broadway, New York 4, N. Y.



Ingersoll-Rand Type 30
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COMPLETE ADAPTABILITY... BRODIE Series 500 Control Valves

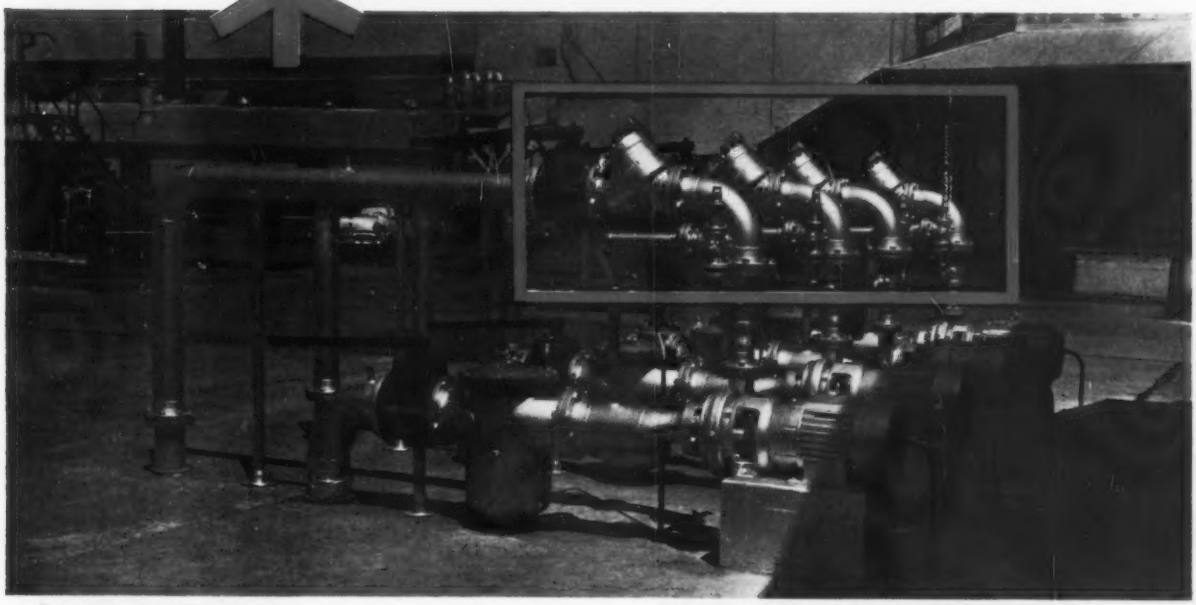

Photo shows a pump installation serving a **BiRotor**-equipped loading rack on the waterfront. Brodie strainers are shown on the pump inlets and Series 500 Valves on the discharge.

INSURE MAXIMAL FIRE SAFETY

With No Fragile EXTERNAL PIPING

The adaptability of the Brodie Series 500 Control valve is ideal for automatic **emergency fire control** and remote operation — with solenoid operated pilot or with hydraulic, air or gas operated pilots. For fire safety, these versatile valves can be circuited into grounding systems. If grounding continuity is broken, the valve will close and pumps will stop.

To eliminate the hazards of fragile external piping, the Series 500 Valves use Brodie's fully self-contained, internal porting of integral pilots.

In addition these valves serve a dual purpose as check valves, keeping lines packed during idle periods. For full details, write for Bulletin 668 — today.

* Remote Control • Diff. Pressure • Rate of Flow • Pressure Relief • Pressure Regulation • Surge Control • Check Valve • Thermal Pressure Relief • Safety Shut-off

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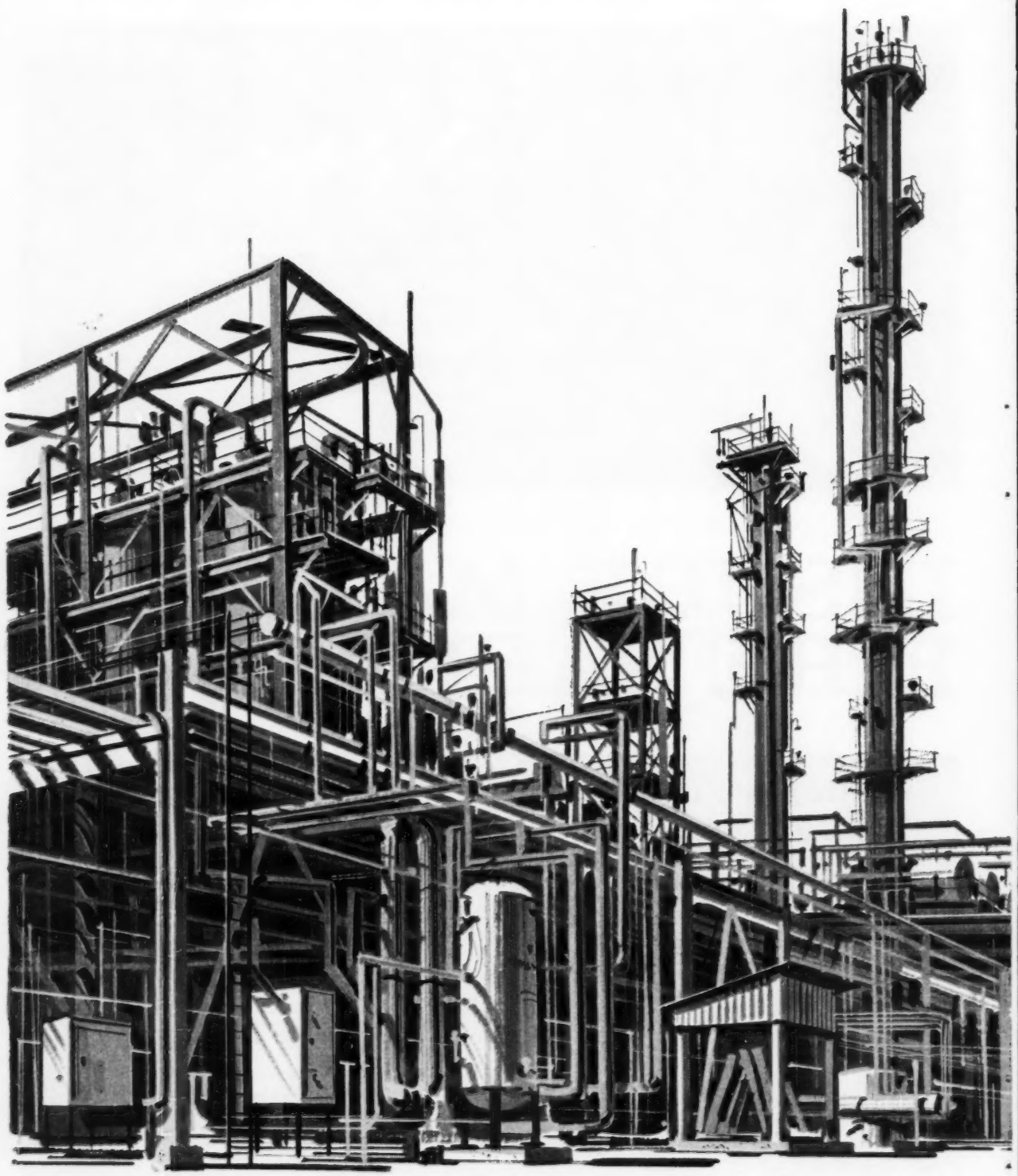

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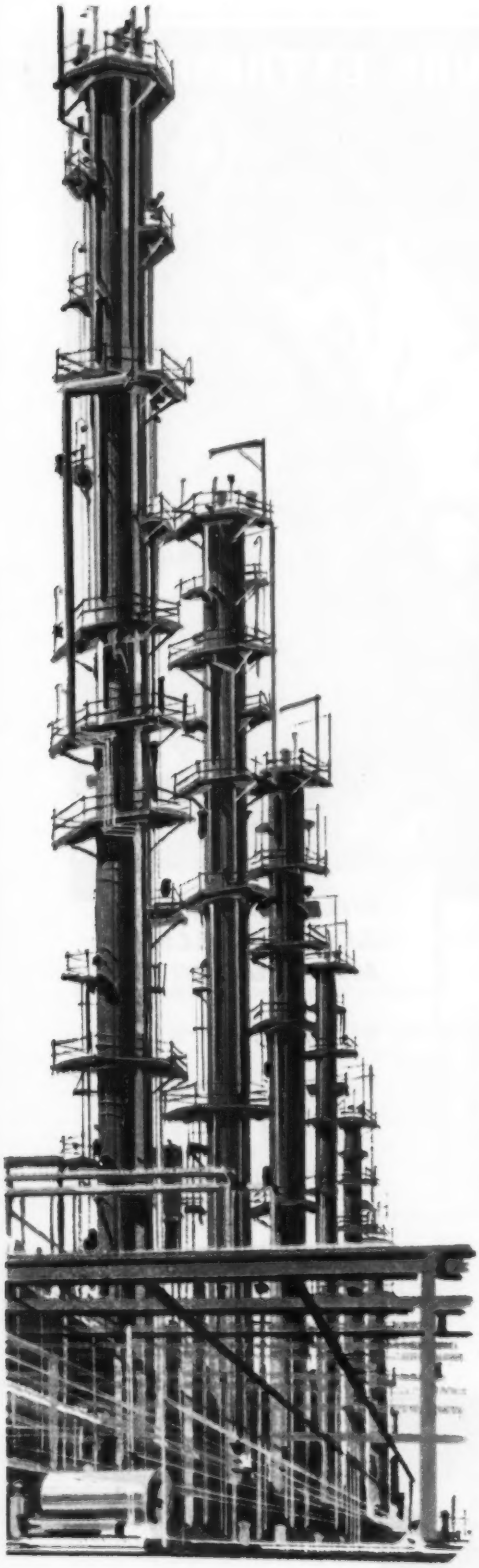

Chemical plant or petroleum refinery?

It takes some, but not a lot of experience, to know at a glance what kind of plant this is. It takes a good deal more to design and build one. And to consistently build profitable process plants demands even greater experience.

Experience in depth means going "on stream" smoothly . . . without long unprofitable start-up. It means long runs that are *designed in* and dependability that is *built in* . . . with low maintenance and truly economic performance.

As your engineering-contractor, Foster Wheeler puts the full measure of 40 years' experience to work for you in the design, engineering or construction of your plant.

Consult with FW's engineering staff when you consider expansion of facilities, plant modernization, or an entirely new installation such as the petro-chemical plant illustrated here. Foster Wheeler Corporation, 666 Fifth Avenue, New York 19, New York.

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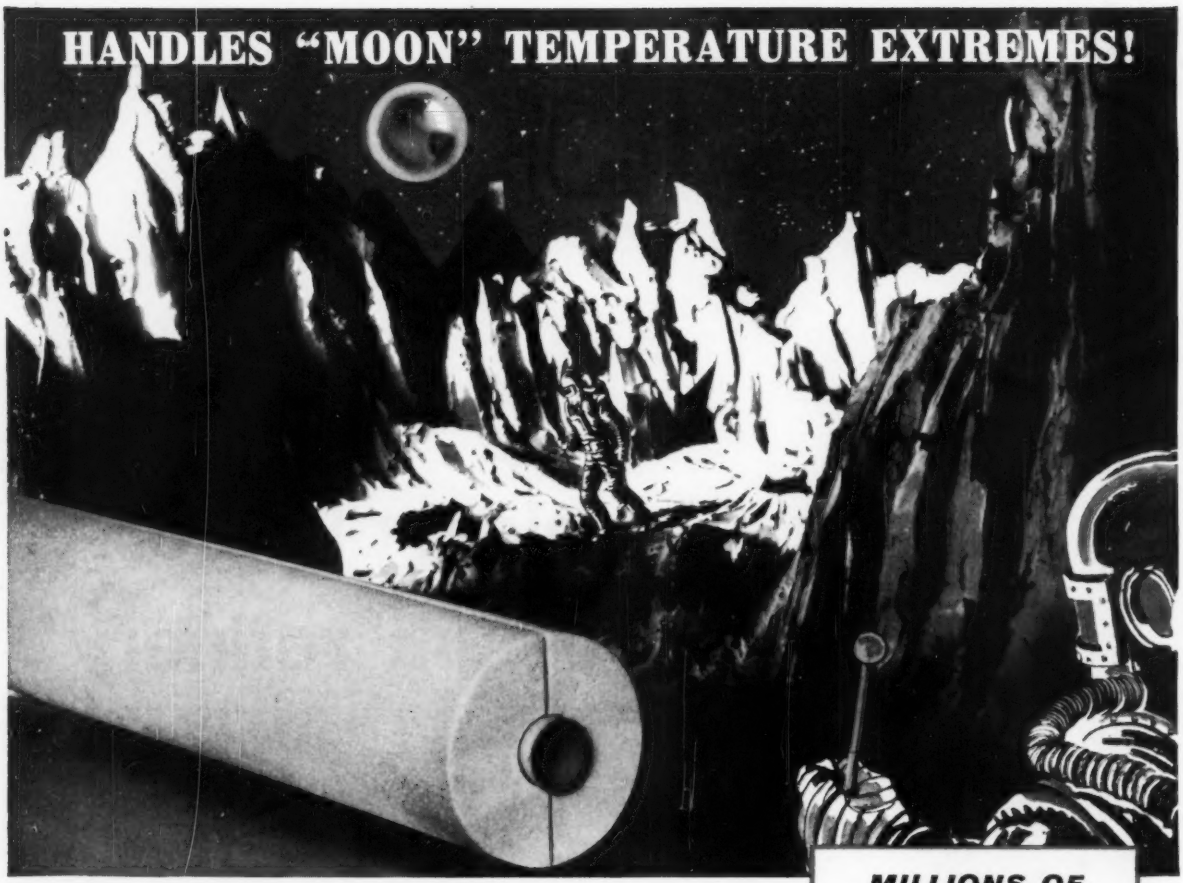
HANDLES "MOON" TEMPERATURE EXTREMES!



New low temperature insulation handles jobs in − 300° F. to + 220° F. range

Of course, this new Unarco U200 insulation is not in use on the moon . . . but it could be, because it handles temperature extremes even greater than would be required on this bleak island in space.* What's more U200 does it without thermal shock effects anywhere along the line.

A new, extremely lightweight, closed cell synthetic, U200 has excellent heat and chemical resistance. Its K factor is only 0.14 at 70° F. mean temperature . . . lowest on the market. Density is only 2.3 lb. per cubic foot. Yet this remarkable, new material has high compressive and flexural strength. It's non-toxic and easy to handle, too.

Try it just once and you'll see how quickly and easily it can be cut and applied with a very minimum of standard hand tools. It can actually reduce application costs by as much as 50%.

Available in accurate, half-round sections; in nominal thicknesses and in standard pipe sizes. Individual sections 36 inches long. Also available in 12" x 36" block form—1" to 5" thickness in ½" increments.

(*) *−243° F. to +214° F. Estimated moon temperatures as listed in a leading American encyclopedia.*

Get complete engineering specifications and other details before another day goes by.

Write today on your company letterhead for Unarco Bulletin No. U200-1.

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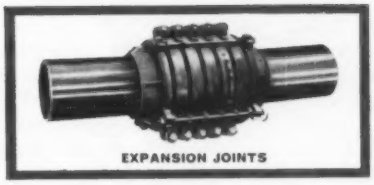
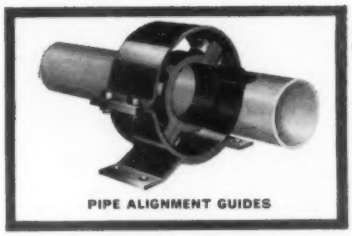
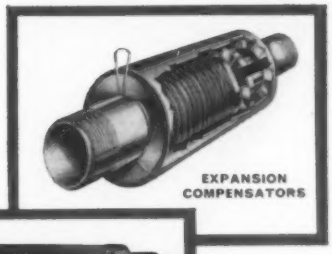
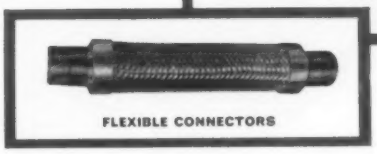
51 SOLUTIONS TO PIPE MOTION PROBLEMS


EXPANSION JOINTS

...only **1** source brings you all of them!


PIPE ALIGNMENT GUIDES


EXPANSION COMPENSATORS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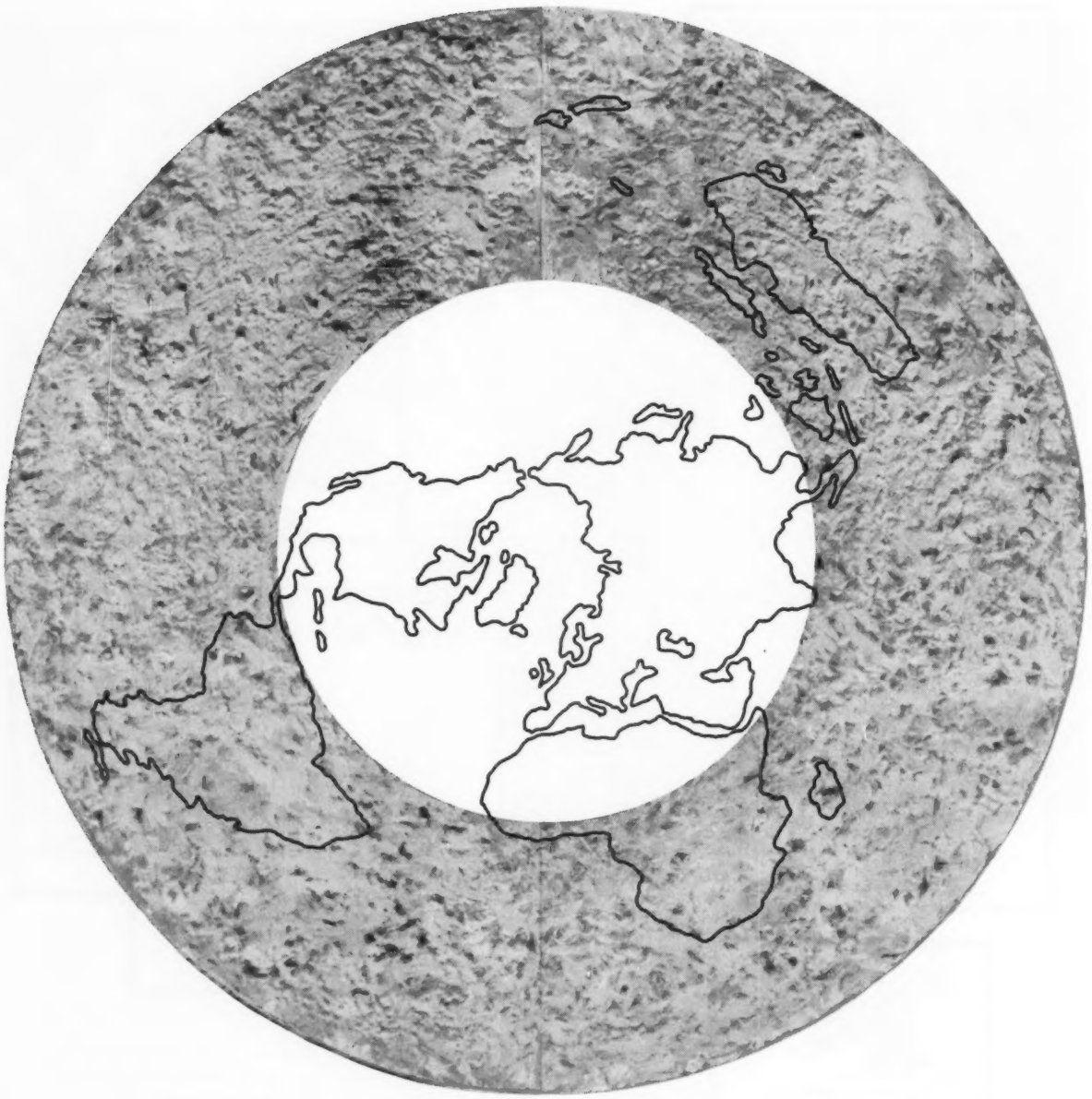

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—and to the same specification

Caposite amosite asbestos is manufactured under supervision to the same uniform specification in all these countries.

Great Britain	by Cape Insulation & Asbestos Products Ltd
Canada	by Caposite Insulations Ltd
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Australia	by James Hardie & Company Ltd
France (as 'Isolamiante')	by Isolamiante SA
Italy	by Capamianto SpA
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Amosite asbestos insulation is also manufactured in U.S.A. under the name of 'Unibestos' by Union Asbestos Rubber Company.

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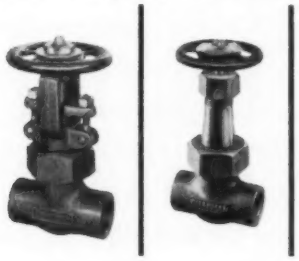
TA.3612

ENGINEERED TO "TAKE CARE OF ITSELF"...

In valves, "forgetability" is a true measure of worth. "Forgetability" is defined in terms of those qualities which allow a valve, once installed, to be almost forgotten. It results from perfection of performance, and year-after-year dependability; combined with less than moderate maintenance requirements. These characteristics are the outgrowth of knowledgeable design and excellence of materials . . . both are tradition with Chapman Valves.

Product of an all-inclusive development program by Chapman, the *originators* of forged steel gate valves, the 960B represents the integrity in design, thoughtful selection of materials, and pride in workmanship which have made their name synonymous with quality valves since 1875.

New Chapman 960B Rugged-Duty Forged Steel Gate Valve



Wheel . . . cast ductile iron. **Stem** . . . heat-treated stainless steel; backseats in bonnet. **Yoke Sleeve** . . . corrosion resistant Chapman alloy CV510. **Follower and Gland** . . . socket and ball type: bind-proof follower; stainless steel gland. **Eyebolts** . . . stainless steel; swing-down design. **Yoke** . . . "bowlegged" design for exceptional hand room. **Stuffing Box** . . . bigger, with special, heavy-duty packing **Bonnet and Body** . . . forged carbon steel. **Male-Female Joint** . . . for precise alignment; makes gasket blowout impossible. **Gasket** . . . asbestos filled, spiral-wound, flexible stainless steel ribbon. **Disc-Stem Connection** . . . sliding joint prevents load transfer. **Disc** . . . hardened stainless steel; guided travel. **Seat Rings** . . . shoulder type, Stellite-faced stainless steel. **Universal Trim** . . . all standard services; temperatures to 1000°F; pressures to 2000 psi.

PRESSURES TO 2000 PSI ☐ TEMPERATURES TO 1000 F ☐ SIZES ¼ TO 2 IN. ☐ UNIVERSAL TRIM FOR ALL SERVICES

CHAPMAN VALVE

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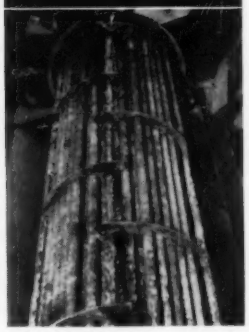
another

TRETOLITE SERVICE report

Midwestern refinery "saves a bundle" with KONTOL* *Corrosion Inhibitor*

Before KONTOL treatment, —in service 76 days.



After 295 days' service, with KONTOL treatment.

Both ways—in dollars and in actual equipment—this refinery "saved a bundle" in its crude unit heat exchange section by adopting a KONTOL* protection program.

Heat exchange was inefficient and tube life was short. Then KONTOL Corrosion Inhibitor was injected into the overhead line ahead of the condensers.

Here are the bundle-saving results:

- Tube bundle life was *tripled* by drastic curtailment of corrosion.
- Heat savings amounted to *6,000,000 BTU's per hour*, as a result of KONTOL's powerful detergent action.
- Estimated cost of heat loss was $96 per day prior to use of KONTOL. KONTOL protection eliminated this loss for only $20 per day—a savings of nearly 5 times the cost.

KONTOL Corrosion Inhibitors are protecting tube bundles, and saving bundles of money, for refiners all over the world. Ask your Tretolite Field Service Engineer (the "Man in the Red Car") for more details.

*Registered trademark of Petrolite Corporation

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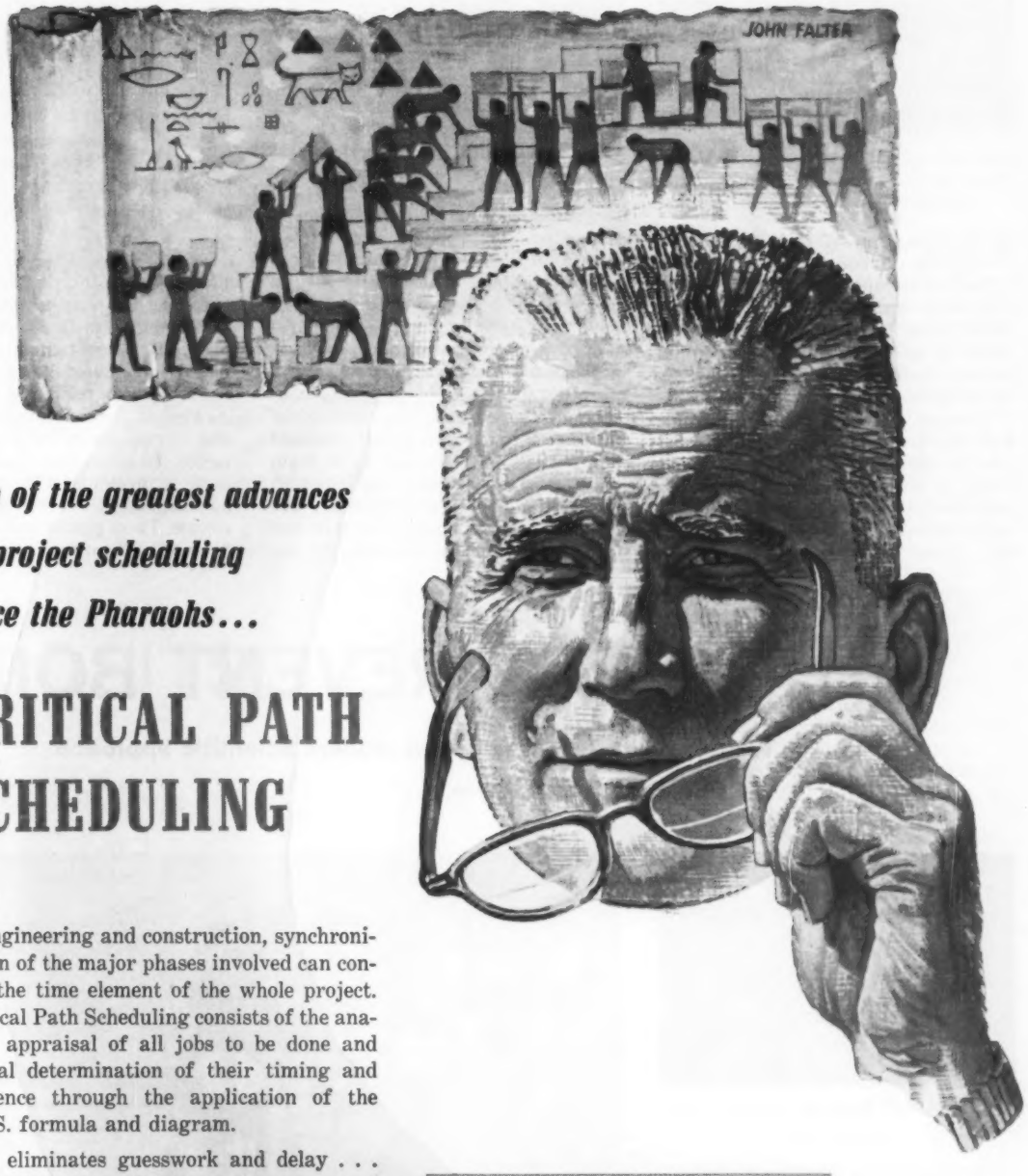

One of the greatest advances in project scheduling since the Pharaohs...

CRITICAL PATH SCHEDULING

In engineering and construction, synchronization of the major phases involved can control the time element of the whole project. Critical Path Scheduling consists of the analytic appraisal of all jobs to be done and logical determination of their timing and sequence through the application of the C.P.S. formula and diagram.

This eliminates guesswork and delay . . . guarantees an uninterrupted program of production from early design to completed construction.

Result—important savings in time and cost.

CATALYTIC has pioneered this modern scheduling method with very significant results.

We would welcome your inquiries as to how C.P.S. may apply to your construction, expansion, maintenance or modernization plans.

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HELPFUL WATER CONDITIONING DATA FROM BETZ

HOW TO PREVENT BOILER

Troubled with boiler scale? A modern scientific approach will eliminate the problem.

THE FORMATION of scale and sludge deposits on boiler heating surfaces is the most serious problem encountered in steam generating equipment. Blistered boiler tubes and tube failures cause boiler outage and loss in production. In extreme cases, complete shut-down of an entire plant can result.

Through the years, industrial plants have found it more economical to generate steam at higher and higher pressures. At the same time, heat transfer rates have increased to aggravate further the problem of scale and deposit formation. Water treatment technology has kept abreast of these increasing demands by developing more effective external and internal treatment methods.

Softening Process	Residual Hardness, ppm
Cold Lime-Soda	30-50
Hot Lime-Soda	15-25
Hot Lime-Zeolite	0-2
Zeolite	0-2
Sodium-Hydrogen Zeolite	0-2
Demineralizers	0-0.5

Figure 1

Figure 1 lists the more common external treatment methods that are employed and the range of residual hardness that usually results. The selection of the method of external treatment is governed by the operating pressure, water characteristics, economics and other factors. Obviously, the higher the operating pressure the more complete must be the job of external conditioning. However, no system of external treatment is in itself adequate protection against boiler scale without the use of supplementary internal chemical treatment of the boiler water. Even the small amounts of hardness present in the effluent of zeolite softeners will produce troublesome deposits.

Mechanism of Scale Formation

Basically, scale formation occurs because the solubility of the scale forming salts decreases as temperature increases. Consequently, the higher the temperature (and pressure) of boiler operation, the more insoluble become the scale forming salts. The chief mechanism of scale formation is the result of crystallization of the scale forming salts from the thin, viscous film of boiler water adjacent to the heating surface where the bubbles of steam originate. The generation of steam bubbles produced by vaporization of the water film causes the dissolved substances in the film to concentrate. Consequently, the solubility of the scale forming salts is first exceeded in this thin film rather than in the main body of the boiler water. The salts with the least solubility will crystallize out first and scale will form on the tube surfaces even when the solubility of the scale forming salts is not exceeded in the boiler water proper.

The calcium and magnesium salts are primarily responsible for scale deposits. With untreated boiler water calcium silicate, calcium sulfate and calcium carbonate will crystallize on the tube surfaces as a hard adherent scale. Magnesium salts deposit primarily as magnesium silicate and magnesium hydroxide.

Prevention of Scale

Prevention of the crystallization of scale-forming salts from the thin film adjacent to the heat transfer surface is accomplished by precipitating the calcium and magnesium salts in the main body of the boiler water in their least soluble form. As a result, the concentration of calcium and magnesium in the film will be negligible. To accomplish these results, calcium is precipitated as the phosphate and magnesium as the hydroxide and/or silicate. These precipitates can settle and bake on the heat transfer surfaces in the

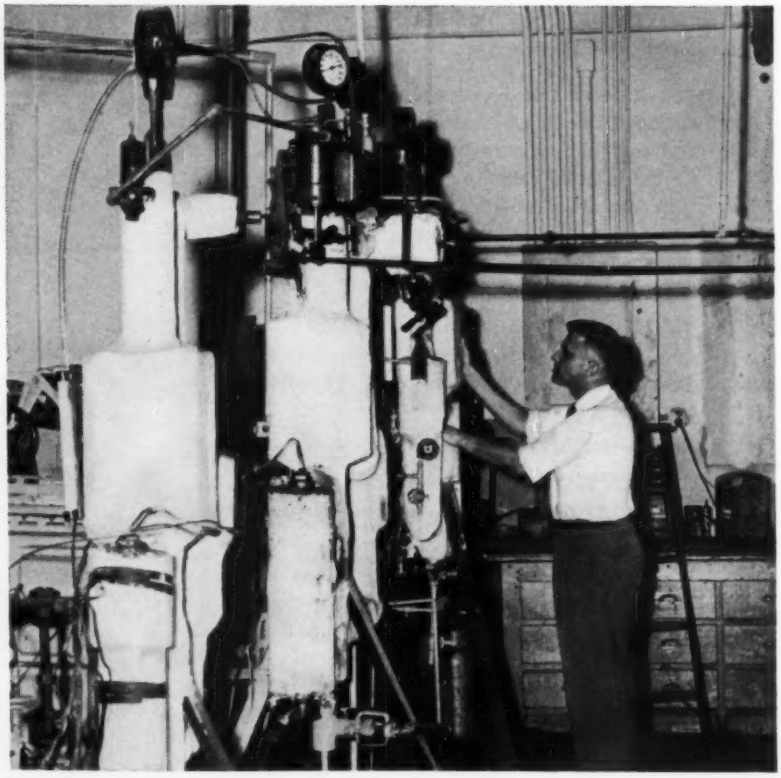
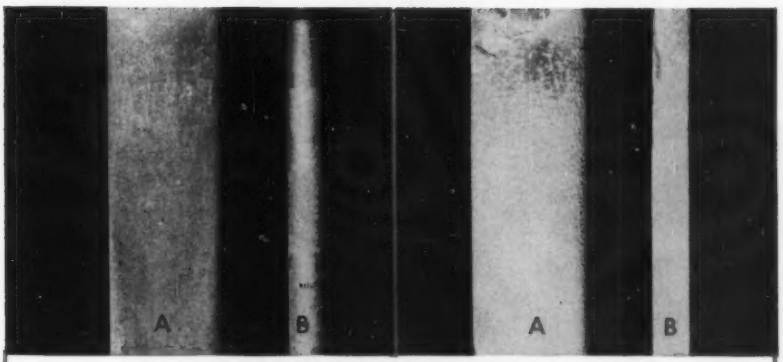


Figure 2—Experimental boilers.



Deposit, grams per sq ft.			
With Sludge Conditioner		Without Sludge Conditioner	
A	B	A	B
0.03	0.12	1.20	5.80

Heat transfer A=28,000 Btu/sq ft/hr; B=180,000 Btu/sq ft/hr

Figure 3

DEPOSITS

form of objectionable deposits, unless they are maintained in a dispersed form as a fluid, non-adherent sludge. Accordingly, further conditioning of these precipitates by organic dispersing agents serves to convert them to a sludge that can be removed by boiler blowdown.

Organic Sludge Conditioners

Starches, tannins, lignins, colloids and other organic agents possess to a varying degree the ability to maintain calcium and magnesium precipitates dispersed in the form of sludge. The ability of various organic agents to accomplish sludge conditioning has been the subject of extensive research. At Betz Laboratories, specially designed experimental boilers such as those shown in Figure 2, are used to develop the most stable and effective sludge conditioning agents available.

These experimental boilers are equipped with feed systems, water level control, blowdown and the safety devices necessary for continuous, automatic operation. The heat input is accomplished by electrical heating elements which serve as the scaling surfaces and have heat transfer rates ranging between 28,000 to 180,000 Btu per square ft. per hour. Figure 3 shows the low and high heat transfer scaling surfaces from a duplicate experiment with and without the use of an organic sludge conditioning agent. The effectiveness of the organic sludge conditioning agent is readily evident.

Other Deposits

Another source of concern is silica. Complex silica deposits, which may or may not include calcium and magnesium in their structure can occur in boilers operating at high pressures and at high heat transfer rates. The silica tolerances for various boiler operating pressures have been well established for prevention of boiler scale and for prevention of silica vaporization with the steam.

Blowdown can be used to control silica concentrations to the proper tolerance levels. When excessive blowdown is required, external silica removal processes should be employed to restrict boiler water silica concentrations within established limits.

The concern for silica is not always because it is too high. In some cases silica can be too low. This situation occurs primarily with waters that contain high magnesium concentrations and low silica values. In these special cases magnesium will tend to precipitate as magnesium phosphate which produces a sticky sludge. Precipitation in this form is aggravated when the feedwater enters in a region of low alkalinity and poor circulation. Under these conditions, increasing the silica content of the feedwater to avoid magnesium phosphate precipitation will prove helpful. However, this practice must be applied within the normal silica tolerances established for the boiler operating pressure. Other factors that must be considered are increased boiler water alkalinity, the use of special organic sludge condition agents and better mixing of the feedwater.

Iron Oxide Deposits

Deposits consisting predominantly of iron oxide are frequently found in boilers operating with very pure feedwater. In such plants, the makeup water requirements are usually low. The usual sludge forming calcium and magnesium salts may amount to less than 5% of the boiler deposit. The origin of such deposits can usually be traced to corrosion external to the boiler. Corrosion of iron or steel in the condensate or preboiler system will permit substantial amounts of dissolved iron to enter the boiler where precipitation will occur as a result of the higher temperature and alkalinity conditions of the boiler water. Prevention of iron oxide deposits originating from corrosion external to the boiler can most effectively be controlled by eliminating the condensate corrosion problem. The materials most commonly employed for this purpose are the neutralizing or filming amines. Where carbon dioxide concentrations are low and dissolved oxygen negligible the neutralizing amines will prove effective and economical. Where carbon-dioxide concentrations are high the use of the filming amines will prove more effective and economical.

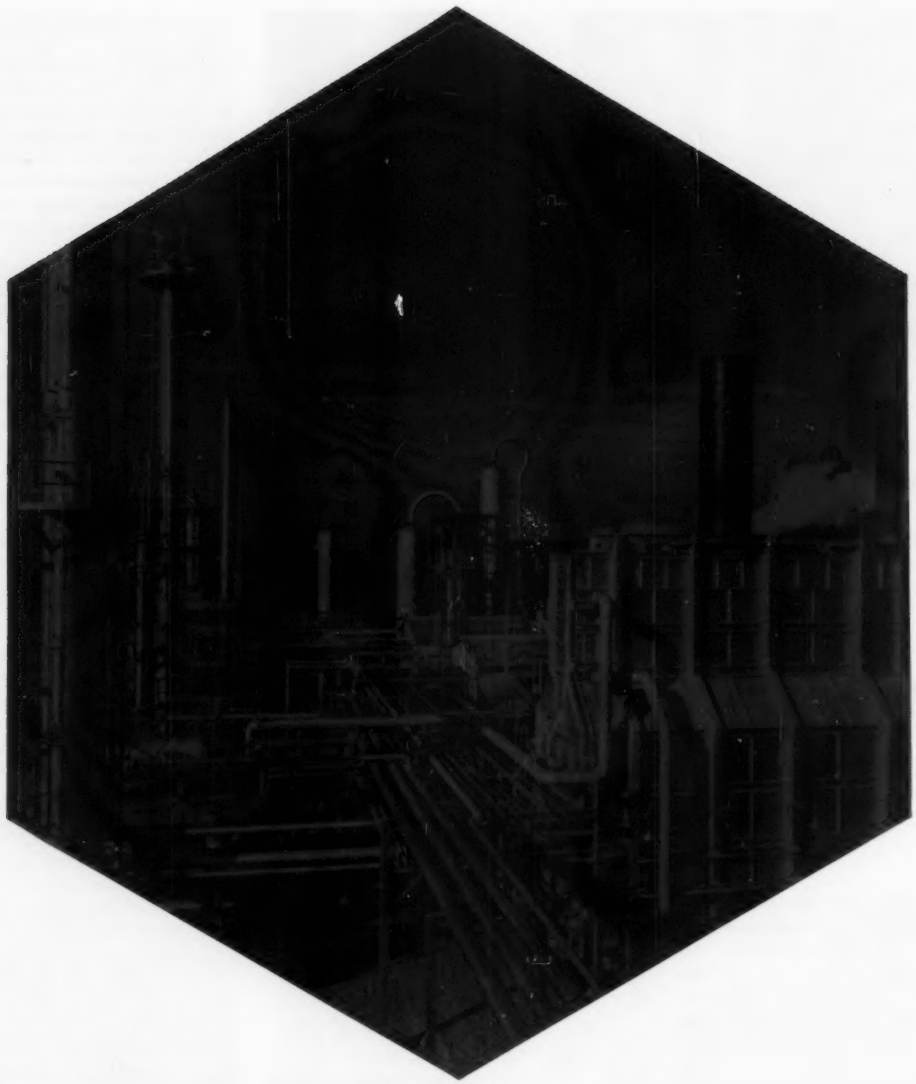
Iron oxide deposits originating from attack of the boiler metal can also result. One special case of such attack occurs from steam blanketing. The water and steam oxidize the hot steel to black magnetic oxide at hot spots in the boiler. These problems are associated with extreme heat input and faulty or low circulation and usually lead to tube failures.

Betz research has produced the products and know-how to handle all phases of your boiler water conditioning problems effectively and economically. If you would like additional information regarding Betz service at your plant, we will be happy to have you write us. Why not do it *today?*

BETZ LABORATORIES, INC.

PHILADELPHIA 24, PENNSYLVANIA

CONSULTANTS ON INDUSTRIAL WATER PROBLEMS



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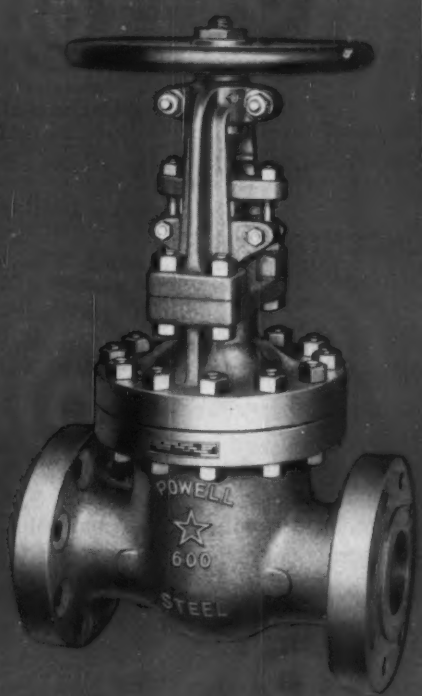
175-pound W.O.G. Semi-Steel Lubricated Plug Valve, Fig. 2201. This is a single gland type valve with flanged ends and is wrench operated. Sizes, 1" through 4". Available also with screwed ends. Also available in carbon steel and with flanged or screwed ends.

600-pound Steel Gate Valve, Fig. 6003. Outside screw rising stem and yoke. Bolted flanged bonnet, flanged ends. Accurately guided solid wedge disc, renewable seats. Can be supplied with welding ends. Sizes, ½" through 24".



150-pound Steel Swing Check Valve, Fig. 1561A. Bolted cap, flanged ends. Can also be furnished with welding ends. Permits full flow through the valve when disc is in wide open position. Sizes, ½" through 16".

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NEW TOOLS FOR FORMULATING HEATING OILS

PARADYNE® HO-10 and PARADYNE® HO-20 POUR DEPRESSANTS

FOR THE REFINER

Greatly increased freedom to adjust operations and inventories to meet changes in demand. More kerosene available for jet fuel, diesel fuel or other high value outlets. More high pour components receiving heating oil instead of fuel oil value.

FOR THE MARKETER

An end to costly operating difficulties formerly unavoidable in cold weather. Unprecedented flexibility in utilizing available heating oil inventory in almost any weather.

EFFECTIVE AT LOW CONCENTRATIONS

Paradyne HO-10 and Paradyne HO-20, in concentrations of only 0.01 to 0.1 weight per cent can lower ASTM pour points of heating oils variously by 10 to more than 70 degrees Fahrenheit. Either one or both have been found effective in over 90 per cent of stocks tested.

HOW THEY WORK

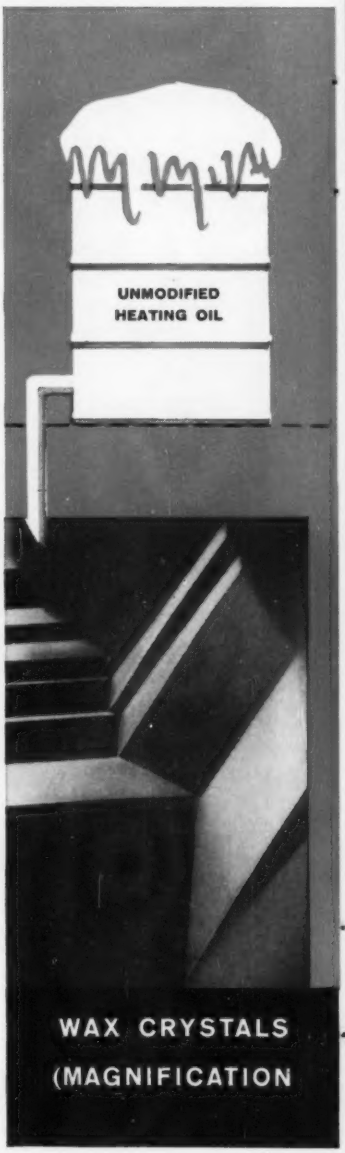
Paradyne HO-10 and Paradyne HO-20 – both designed specifically for use in heating oils – drastically modify the size and structure of wax crystals formed when heating oil is cooled below its cloud or pour point. The pictures in the centerfold demonstrate their effect.

WINTER FIELD TESTS REVEAL OUTSTANDING EVIDENCE...

In addition to extensive laboratory tests, a wide range of field tests have been carried out in Canada and Maine during severe winter climate.

Two heating oils having natural pour points of 20°F and –5° were both depressed with Paradyne HO-20 to –45°F and –40°F. The fuels were evaluated for low temperature flow properties in 12,000-gallon storage tanks, in tank truck deliveries, and in 524 home heating units.

Even though the ambient temperature reached –30°F, good operability was obtained in storage, delivery and customer units.



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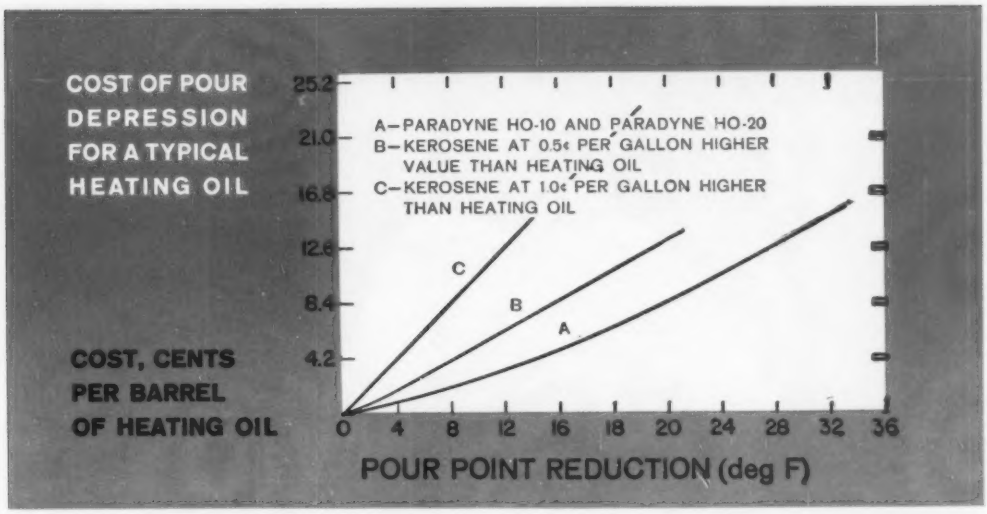
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COST, CENTS PER BARREL OF HEATING OIL
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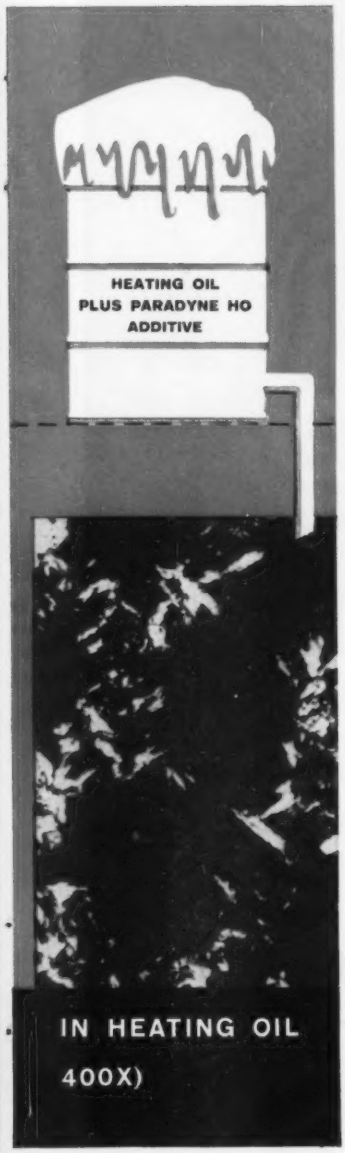
21.0
16.8
12.6
8.4
4.2
A—PARADYNE HO-10 AND PARADYNE HO-20
B—KEROSENE AT 0.5¢ PER GALLON HIGHER VALUE THAN HEATING OIL
C—KEROSENE AT 1.0¢ PER GALLON HIGHER THAN HEATING OIL
C
B
A
0 4 8 12 16 18 20 24 28 32 36
POUR POINT REDUCTION (deg F)



AND HERE'S HOW THESE ENJAY ADDITIVES STACK UP IN COST AGAINST KEROSENE...

The cost of lowering the pour point of a typical heating oil with Paradyne HO-10 or Paradyne HO-20, compared with kerosene may be seen here at a glance.

BLENDING FLEXIBILITY

Paradyne HO-10 and Paradyne HO-20 may be added to heating oil at any point in the distribution system—at the refinery, bulk plant or at the local terminal.

EASY EVALUATION OF EFFECTIVENESS

It's easy to determine which and how much new Paradyne HO additive to use by simple ASTM pour determinations:

1. Test the response of heating oils to both additives.

2. Evaluate heating oil responses over a range of additive concentrations.

3. Vary proportions of various stocks to be blended in the finished fuel. Generally, to effect maximum savings, evaluate the effect of high-pour components on blends.

COMPOSITION AND APPEARANCE

Both Paradyne HO-10 and Paradyne HO-20 are approximately 50% concentrates of active ingredient in kerosene. Both are liquids at room temperature.

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ENJAY ADDITIVES

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HUPP ELECTRODYNE
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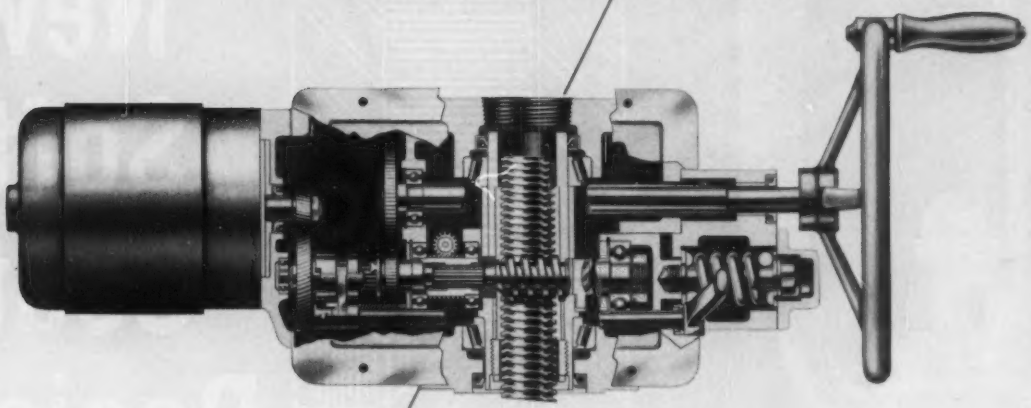

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HUPP *Electrodyne* Valve Control (formerly CUTLER-HAMMER Valve Control) is available in controlled torque type units with a range of 3,000 to 300,000 pounds thrust, with larger sizes on application.

The TN-2 Series features a double acting mechanical torque limiting switch which provides for obstruction protection in both directions of valve travel. An automatic handwheel declutching mechanism is standard.

Self-contained starters and push buttons with indicating lights are mounted in the explosion proof enclosure. Up to sixteen contacts are available for control. Position indicators, position transmitters and receivers are available as optional equipment.

For detailed information, write for Electrodyne Valve Control Bulletin. Parts and service are available promptly through HUPP *Electrodyne* representatives from coast to coast.

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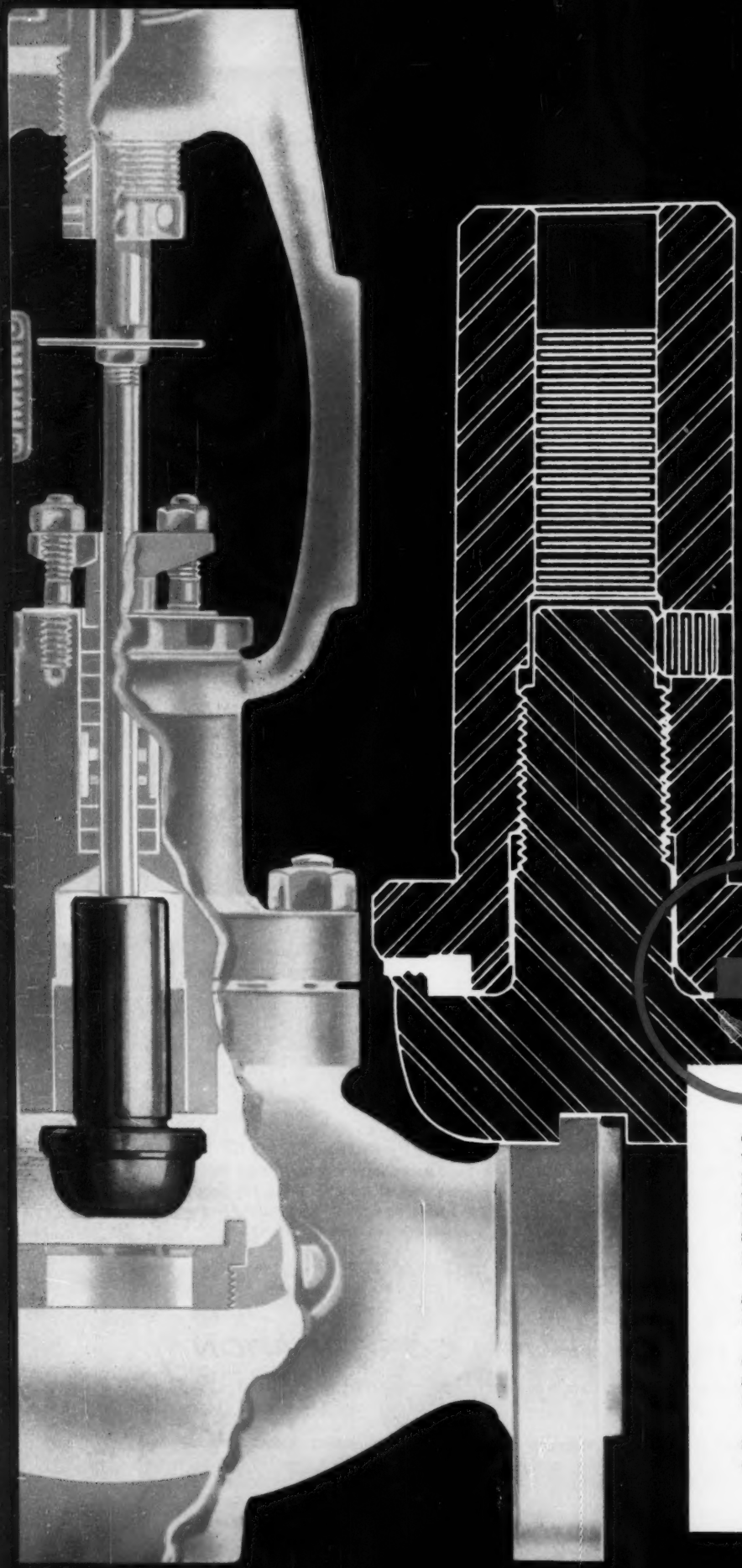


New Soft-Seat Design...

The soft-seat design provides tight shut-off through the normal flow path and a seal to prevent leakage through the threaded parts. The insert is fully retained in closed position, and is held with sufficient force to prevent blowout even at differential pressures in excess of 1000 psi. The insert is protected by metal-to-metal backup.

Soft-seat plugs are available in nominal sizes from 1″ to 10″. Inserts may be of Buna-N, Teflon or Glass Filled Teflon.

These materials are long lasting under conditions for which they are designed. Inserts may be replaced and materials are interchangeable.

20000 Series Valves may be converted to soft-seat trim in the field by installing plug and ring sets.

NOW!

The Advantages of 20000 Series Valves plus

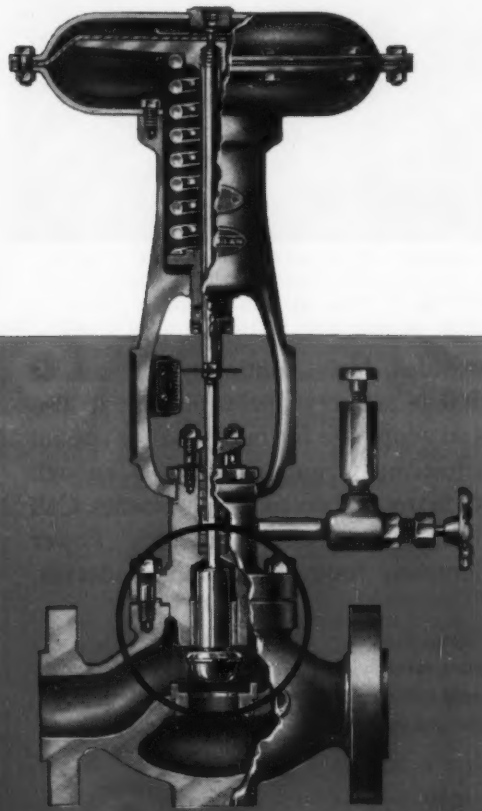
TIGHT SHUTOFF

without Sacrificing Capacity or Characteristics

Now you can have high-capacity single-seated control valves with soft-seat tightness — without sacrifice of percentage characteristics. This design, moreover, permits static pressures and pressure drops up to 500 psi.

Soft-seat inserts of several materials are available to meet varying conditions. For example: *Buna-N* for temperatures to 200 F; *Teflon* for temperatures to 300 F and resistance to chemicals; *Glass Filled Teflon* for temperatures to 500 F, for high-mechanical strength, corrosion resistance and for steam service. Metals available are identical with those normally used in metal-to-metal seating.

This new trim is a logical extension of the versatility inherent in the 20000 Series, designed to meet the growing preference for single-seated control valves. If you do not yet have information on the most versatile control valves available, ask a Mason-Neilan representative or write —



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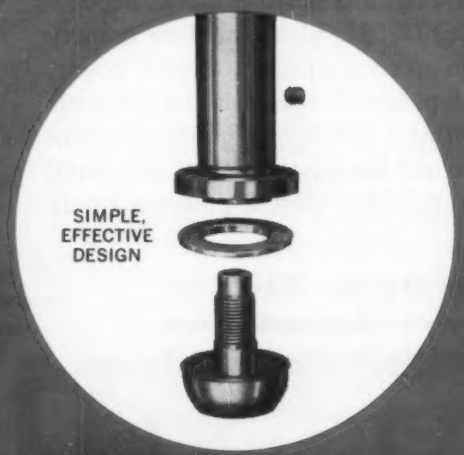

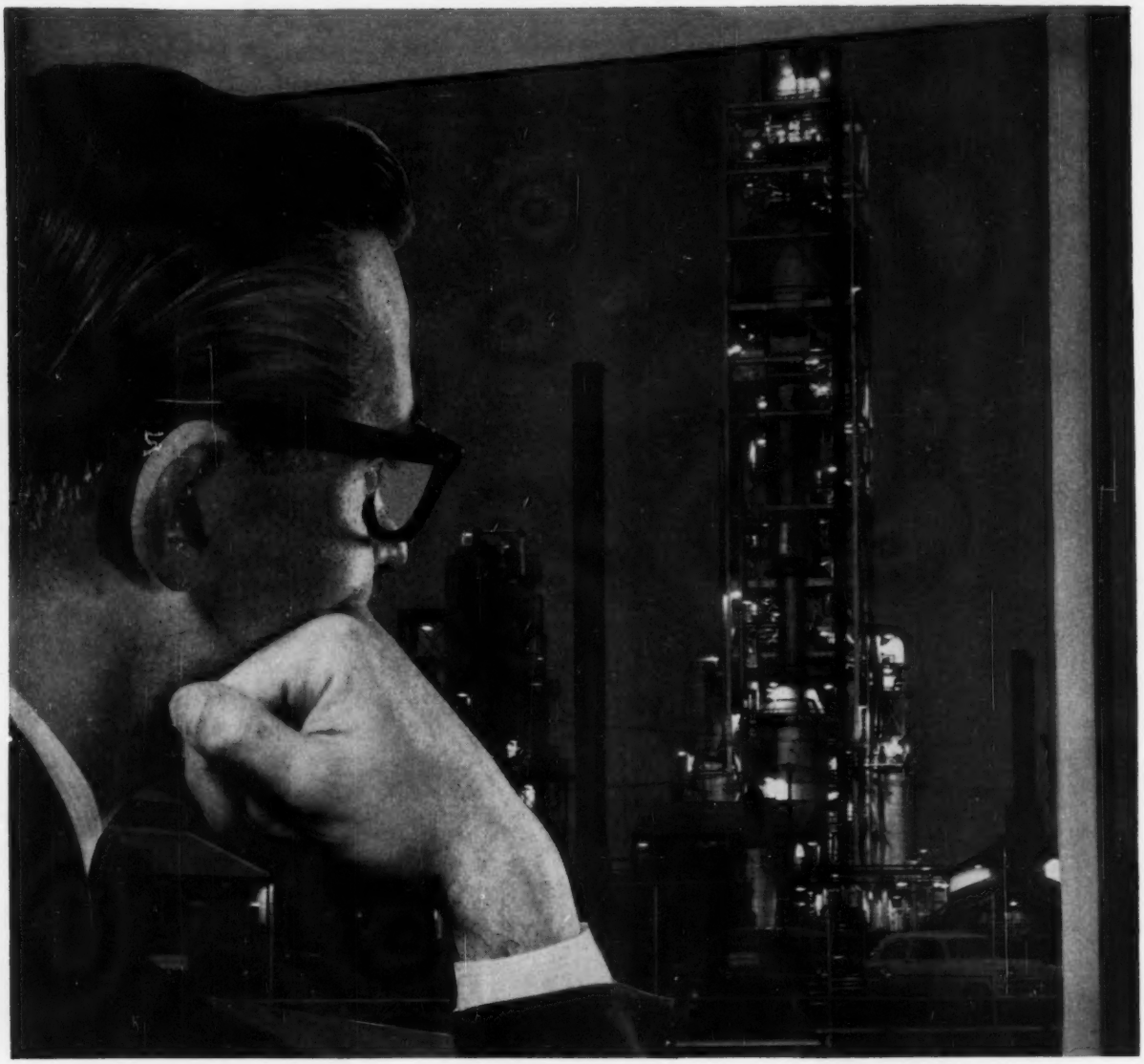

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Providing around the clock dependability for this clean, modern refinery is the presence of utility electric power. In all phases of operation it holds costs down and also brings greater convenience and the advantages of automatic control. Utility electric power not only provides high continuity of service vital in refinery operation, but it also is so adaptable for individual or special requirements and yet flexible enough for many unforeseen requirements. Call your nearest Utility Electric Power Company today for complete details.

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JEFFERSON GAS TREATING BRIEFS

Problem Approach Guide

FOAMING OF ETHANOLAMINE SOLUTIONS

For a quick diagnosis of foaming problems encountered in ethanolamine solutions used for gas treating, the major causes of foaming and their remedial treatments are discussed.

CAUSES OF FOAMING

Foaming of ethanolamine solutions can usually be attributed to contamination by one of the following:

1. Suspended solids.
2. Liquid hydrocarbons.
3. Organic acids in inlet gas which react with ethanolamine to form soap-like materials.
4. Surface-active agents contained in oil field inhibitors, compressor oils, pump and valve lubricants, etc.
5. Ethanolamine decomposition and degradation products.

EFFECT OF FOAMING

Reduction in treating capacity and loss of ethanolamine are the two major problems associated with foaming. Foaming has a direct effect on capacity due to loss of proper vapor-liquid contact, solution hold-up and poor solution distribution. Entrainment and carry-over of amine in the treated gas is not uncommon during foaming.

TEMPORARY FOAM CONTROL

When foaming occurs, it is usually important that an antifoam agent be selected to reduce the foaming tendency of the amine solution until a more permanent remedy can be found. Antifoam agents that work in one plant will not necessarily work in another so it is often necessary to evaluate a number of compounds. Evaluation of various antifoam agents should be done in the laboratory prior to plant use. There are a number of good silicone type antifoam agents that handle a wide variety of foaming conditions. The high molecular weight alcohols and low foaming surface-active agents, such as SURFONIC® N-10, have been used effectively.

REMOVAL OF CONTAMINANTS CAUSING FOAMING

Removal of suspended solids and sludge can best be accomplished by continuous filtration of a sidestream of the circulating amine solution. In heavily contaminated streams, up to 25 per cent of the solution circulated is continuously filtered. As the amount of solids and sludge is brought down to normal operating levels, the amount filtered can usually be reduced to a range of 5 to 10 per cent with good results.

There are numerous types of filters available that are capable of performing a satisfactory job. The most popular type filters are those using either a precoat or disposable filter cartridges. When precoat filters are used in systems having a normal heavy load of insoluble matter, continuous injection of the precoat slurry into the amine feed to the filter can be used to extend filter cycle time.

If foaming is found to be caused by the presence of liquid hydrocarbons, it is probable that contamination is due to either entrainment of liquid hydrocarbons through the inlet separator or condensation of hydrocarbons from the gas phase in the contactor. When the problem is due to entrainment, operation and efficiency of the inlet scrubber should be checked. Condensation of hydrocarbons in the contactor can usually be eliminated by adjusting the temperature of the lean amine solution to the contactor to a level of 10 to 15°F. above the inlet gas temperature.

Presence of organic acids in the inlet gas is fairly well restricted to refinery operations. Some organic acids such as napthenic acid will react with the ethanolamines to produce soap-like compounds which may cause foaming. In these cases, it may be necessary to provide a gas scrubbing or washing operation prior to amine treating.

Some of the most troublesome cases of foaming are caused by minute quantities of surface-active agents of unidentifiable origin. One of the best means of removing these compounds from the ethanolamine solution is treatment with activated carbon. This is usually done by continuous filtration of a portion of the circulating solution through two beds of granular activated carbon arranged in series but piped so that they can be interchanged. Treatment or filtration of 2 to 5 per cent of the circulating solution is usually sufficient. These activated carbon filters are usually sized for a flow rate of 2 to 4 gallons per minute per square foot of cross sectional area. Recommended bed depths are 8 to 12 feet.

Many plants using monoethanolamine are using a semi-continuous batch distillation of a portion of the circulating solution. The amount processed will generally run from 1 to 2 per cent of the amine circulated. This type reclaiming procedure has been widely used to remove decomposition and degradation products from monoethanolamine solutions.

For complete information on Jefferson glycols, ethanolamines, and helpful technical services . . . contact Jefferson Chemical Company, Inc., 1121 Walker Avenue, P. O. Box 303, Houston 1, Texas.

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Test its STRENGTH

NEWTHERM is unusually strong and rigid—a feature of special importance in the larger, more vulnerable sections. Put a sample section or slab on part of your plant and *prove for yourself* its outstanding ability to withstand impact and water damage. See how it withstands rough handling in transit and erection, minimising breakage in shipment and erection by unskilled labour at the most remote sites.

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Even totally immersed in water, NEWTHERM retains much of its strength and rigidity. It does not become deformed when in contact with water, thus work-in-progress need not be covered. Especially on contracts where weather conditions would delay the application of insulation—NEWTHERM is the material to use.

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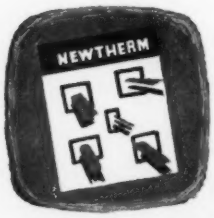
Unusually light for such a high-efficiency material, NEWTHERM compares favourably in this respect with other insulants far inferior in strength. That means easier handling and fewer breakages—even the largest section is easily carried in one hand.

Test its EASE OF APPLICATION

Undoubtedly, NEWTHERM is one of the easiest of materials to apply. It is supplied in plastic form and in a wide range of standard-sized sections and slabs, smoothly finished and straight edged for immediate fitting. The finished job is very neat, with minimum joints, and appliers particularly appreciate the handleability of the material—especially in difficult situations.



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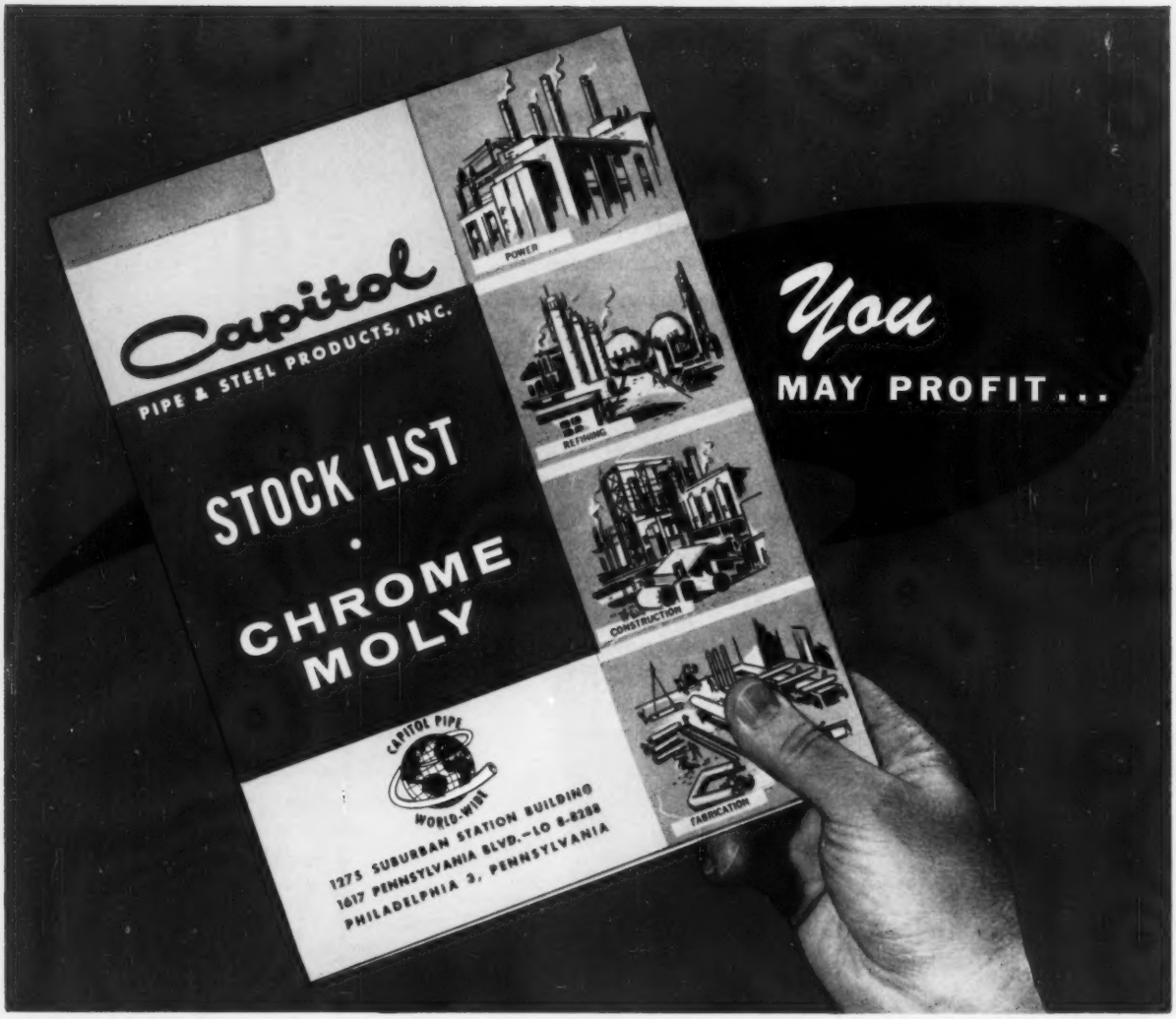

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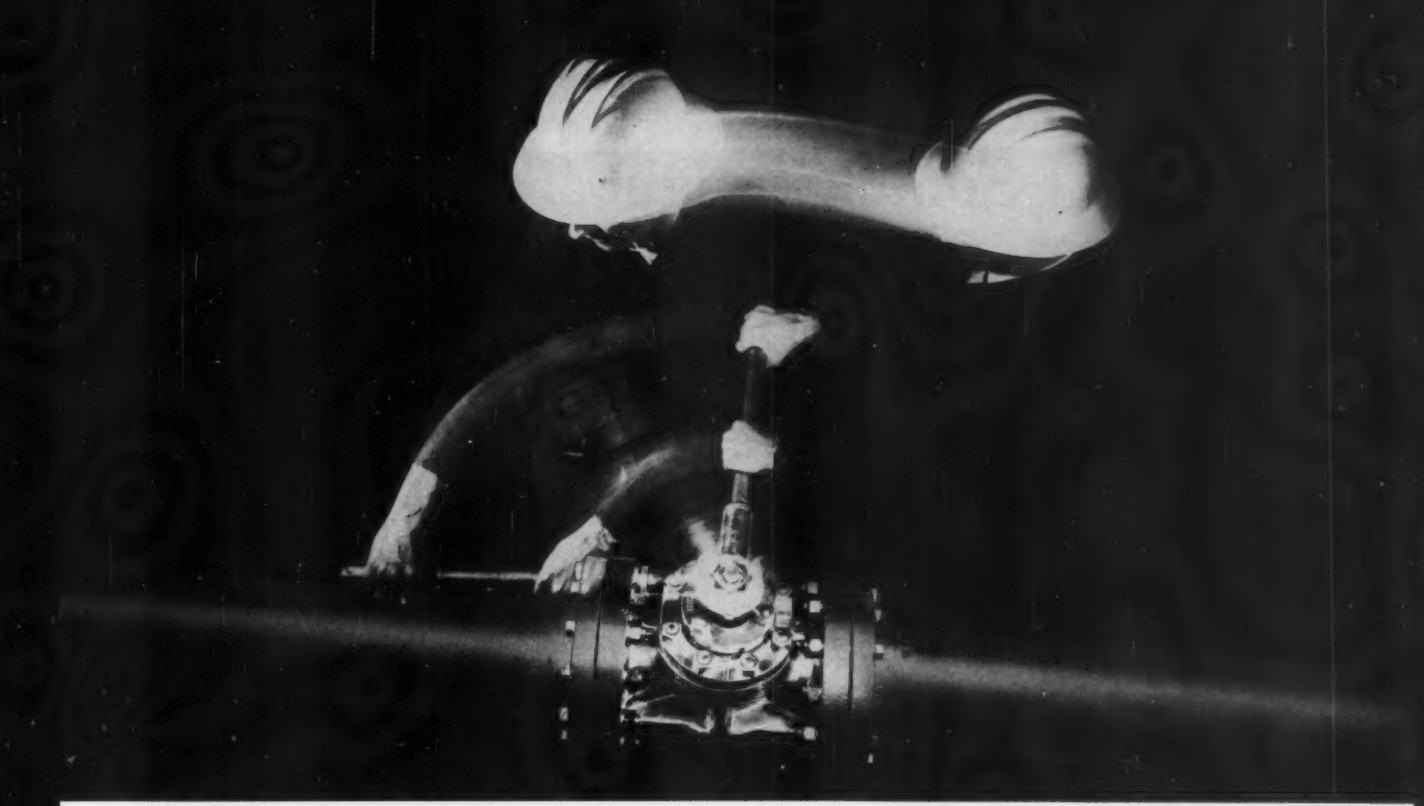

Stroboscopic photo shows fast, smooth quarter turn closure of Rockwell-Nordstrom lubricated plug valves.

THESE LUBRICATED VALVES CLOSE 2 TO 5 TIMES FASTER

Rockwell-Nordstrom *lubricated* plug valves save time, reduce flow control errors because they close quickly, positively and easily with just a quarter turn. One man can open or close a dozen of these valves in the time it takes to laboriously wrestle one hand wheel on other types of valves.

Faster closure isn't the only advantage of Rockwell-Nordstrom lubricated plug valves. Their Sealdport pressurized lubrication system insures positive shut-off by creating powerful seals of hydraulically energized lubricant at the seat ports. And, isn't it just common sense that any lubricated mechanism will work better, longer and at far lower cost than a "dry" one? Get complete details on Rockwell-Nordstrom lubricated plug valves (the world's most complete line) by writing: *Rockwell Manufacturing Company, Pittsburgh 8, Pa.; Canadian Valve Licensee, Peacock Brothers Limited; Rockwell International S.A., Geneva, Switzerland.*

Lubrication Makes The Difference

ROCKWELL-Nordstrom VALVES

another fine product by

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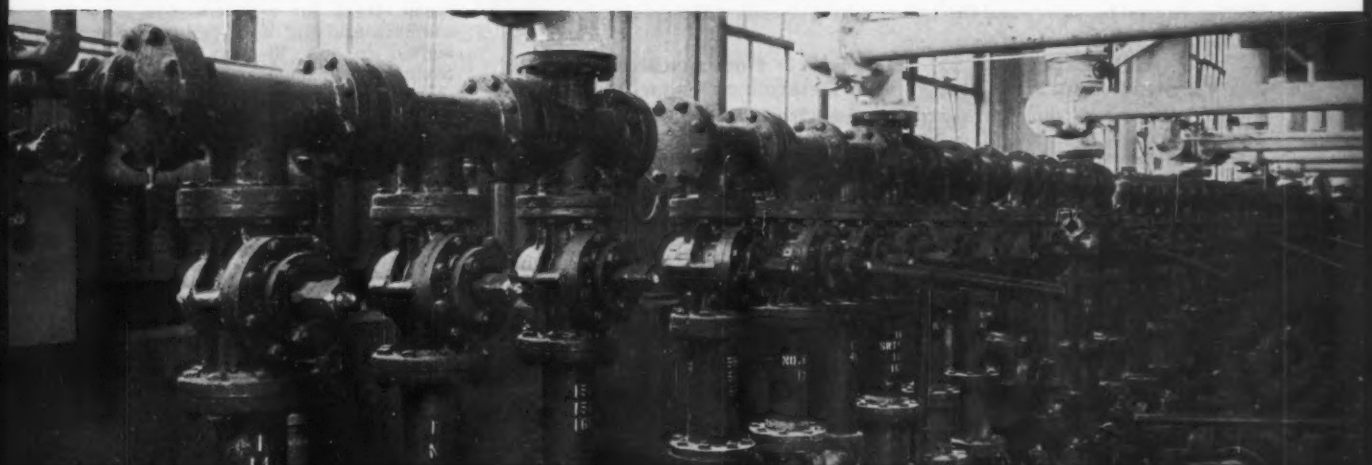


Some Straight Talk On Steam Trap Capacity

...or pulling away the curtain of confusion that surrounds steam trap capacity ratings.

Unfortunately, for the steam trap buyer, the subject of steam trap capacity has become cloudy and confused by a landslide of claims, counter-claims and inconsistent "standards" for measurement. So let's take a cold hard look at this subject so vital to the efficient operation of your plant.

What Determines Steam Trap Capacity?

There are three factors that determine the capacity of a steam trap:

1. The area of the orifice.
2. The density of the condensate.
3. The pressure differential across the trap.

Let's take a closer look at each of these:

Area of orifice is usually specified by the trap manufacturer or can be calculated from the diameter. Nothing complicated here.

Density of condensate depends on temperature. A cubic foot of cold water weighs 62.4 lbs. At 250° F. or 15 psi, it weighs less than 59 lbs. This is important. Don't overlook it.

Pressure differential across the trap is most significant. And it is complicated by the many factors that affect it, such as:

1. Pressure drop between unit drained and the trap when the trap valve is open.

2. Distance the trap valve is moved from the valve seat.

3. Back pressure on the trap with orifice closed; i.e., return header pressure.

4. Increase in back pressure produced by condensate and flash steam flowing in the discharge line. This in turn is affected by the diameter and length of the discharge line, plus friction caused by valves and fittings.

Orifice Capacity Vs. Steam Trap Capacity

Figure 1 shows a ½" diameter sharp-edged orifice at the end of a pipe filled with cold water at 15 lbs. pressure. The capacity of this orifice, using a .61 coefficient of flow would be 8,800 lbs. per hr. Now, would this ½" orifice if used in a ¾" steam trap installed as shown in Figure 2 provide the trap with a continuous discharge capacity of 8,800 lbs. of hot condensate per hour? The answer is "no". And here are some of the reasons why:

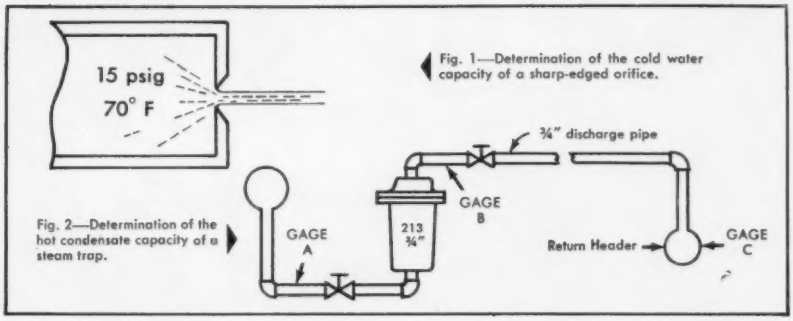


Fig. 1—Determination of the cold water capacity of a sharp-edged orifice.

Fig. 2—Determination of the hot condensate capacity of a steam trap.

Density of condensate. As pointed out above, cold water weighs 62.4 lbs. per cu. ft. At 15 lbs. pressure and 250° F. water weighs less than 59 lbs. per cu. ft. This difference in density alone reduces the lbs. per hour capacity of the orifice by over 5%.

Pressure differential across the trap. With the trap valve closed we have a static pressure differential of 15 psi. The trap valve must be able to open against this pressure. However, this is not the pressure differential that will determine the capacity of the trap valve.

The ¾" discharge line will be full of a mixture of flash steam and condensate. To keep this mixture flowing from the trap outlet to the return line requires a pressure differential. In actual capacity tests run as shown in Figure 2 Gage B at the trap outlet registered 11 lbs. back pressure. Thus the true pressure differential across the trap was about 4 lbs. Under these conditions the measured capacity of the trap was 4,340 lbs/hr. or just about half of the capacity of the ½" orifice for cold water.

How Armstrong Determines Capacity Ratings

Armstrong trap capacity ratings are based on hundreds of tests under actual operating conditions. In these tests, the condensate used was at the steam temperature corresponding to the test pressure. Thus, the capacities determined take into account the pressure drop that occurs when the trap orifice opens and the choking effect and back pressure of the flash steam. Actual installation hook-ups were used so that pipe friction in both inlet and discharge lines as well was reflected in the results.

Let's go back to the example cited above and in Figure 2. The trap referred to is an Armstrong No. 213. While it did test out at 4,340 lbs. per hour for a static pressure differential of 15 psi, it is rated in the catalog at only 3900 lbs. per hour for this pressure—just to be on the safe side.

For the trap buyer, this means that Armstrong Steam Trap capacities are based on handling condensate at steam temperature for the stated static steam pressure differential under actual working conditions.

Capacity ratings which don't take into account all of the variables will be misleading and may lead to the selection of undersized traps. So whenever you specify or buy traps be sure that the capacity ratings you work from are realistic. One way to be sure is to select Armstrong Traps with *guaranteed* capacity ratings.

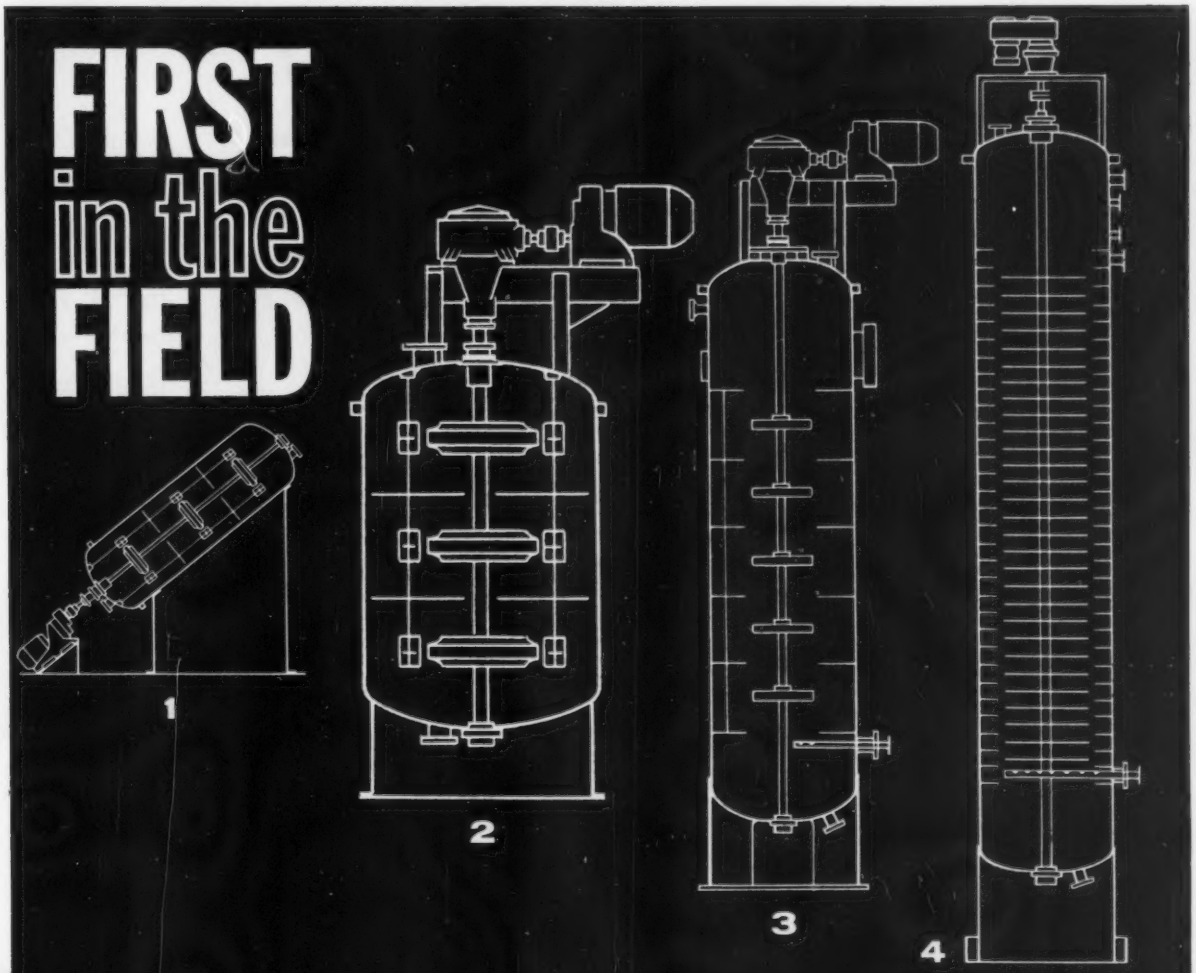
* * *

Additional information on trap capacity ratings, plus data on how to correctly size, install and maintain steam traps for any pressure, any temperature and any load, are presented in the 48-page Armstrong Steam Trap Book. Ask your local Armstrong Representative for a copy or write:

Armstrong Machine Works
8528 Maple Street
Three Rivers, Michigan

ARMSTRONG STEAM TRAPS

FIRST in the FIELD



1 First staged mixer (1933) supplied to industry. Designed and built by Turbo-Mixer.

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3 Concurrent or countercurrent Turbo-Mixer reactor built in any size or number of stages.

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modern, efficient catalytic sweetening

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The effective sweetening of distillates in the gasoline, kerosine, burning oil range can be accomplished by the BENDER process for approximately one-half cent per barrel for all chemical costs, including catalyst maintenance. (Installation cost also is low, ranging from $15 to $30 per barrel/day of throughput.)

Beyond these obvious cost advantages, the Petreco* BENDER process is simple to operate and maintain.

OTHER ECONOMIES OFFERED BY BENDER PROCESSING:

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- *Long catalyst life . . . simple on-the-site reactivation.*
- *No product loss.*
- *Freedom from copper contamination.*
- *Sweet, non-corrosive product.*
- *No stream or air pollution.*

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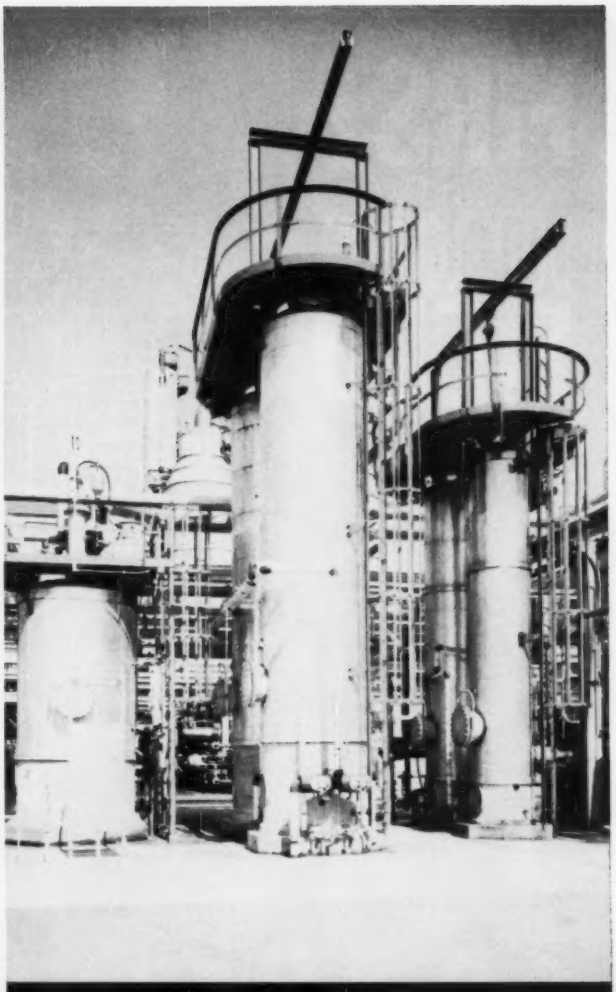
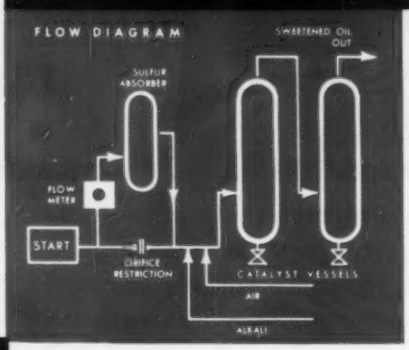


HOW BENDER CATALYTIC SWEETENING WORKS:



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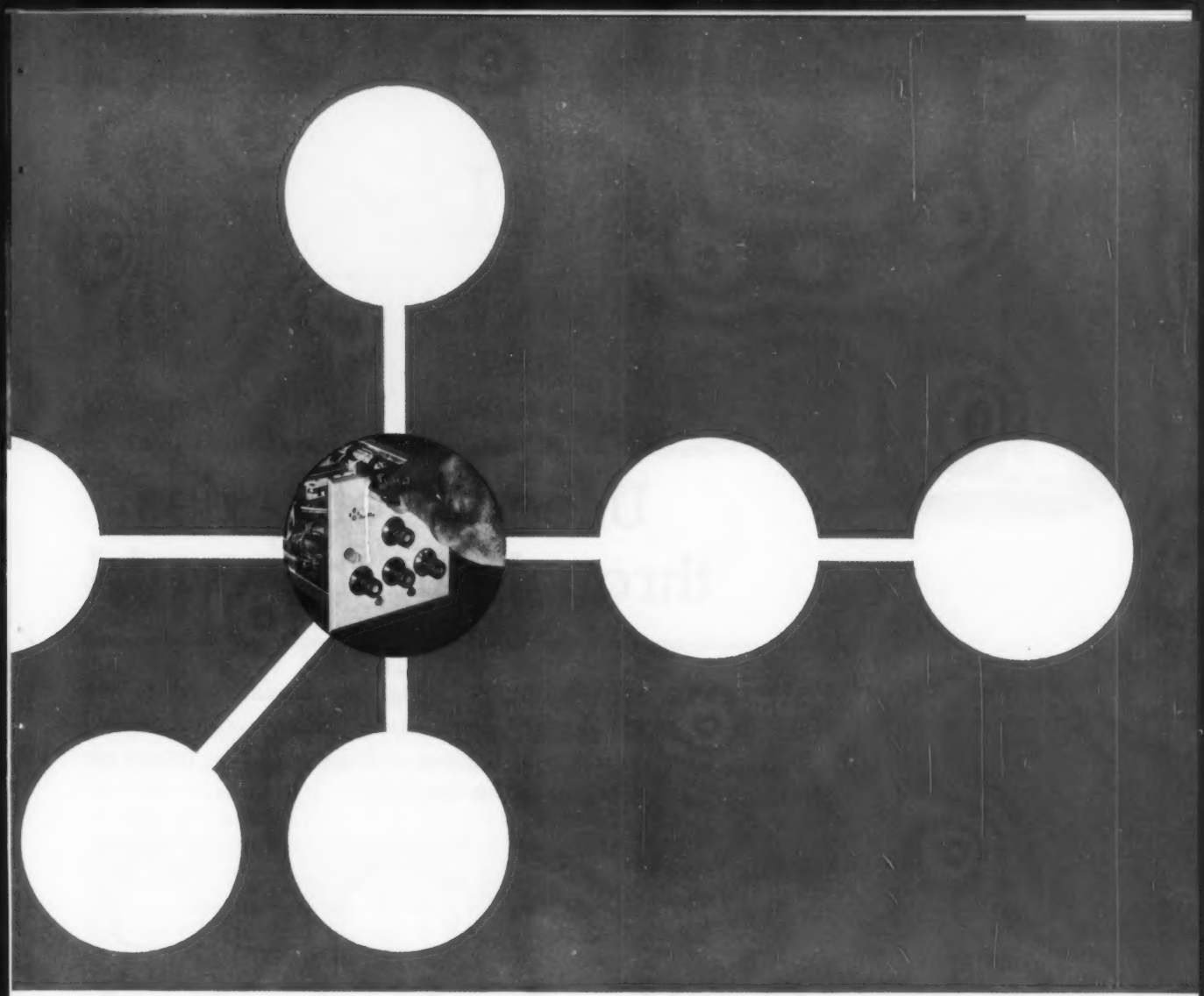


COMPUTER CONTROL?

easy—when the controller is a computer

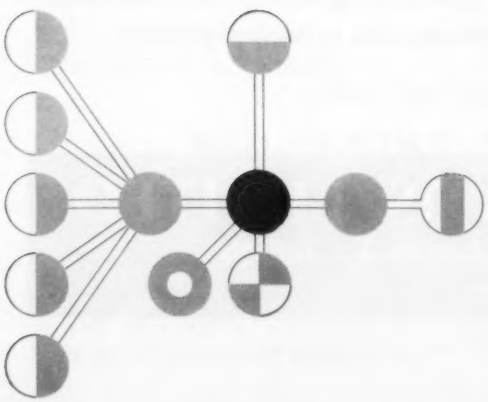
Hagan's PowrMag system is based on the analog computer approach to process control. The core of the system is the controller, and the core of the controller is an *operational* magnetic amplifier. Potted and encased in steel, this high gain amplifier can produce all control actions by means of simple negative feedback through ordinary resistive or capacitive components. These "passive" components are interchangeable and are easily plugged into the basic amplifier chassis by means of an integral plug board.

The basic controller can thus provide functions required for each control loop—addition, subtraction, gain, rate action or integration.

This modular construction reduces inventory problems, and provides a high degree of flexibility. Since the system uses high level DC voltages, noise, capacitive loss and phase shift problems are eliminated. Power consumption is low—about 3.5 watts per unit, and the power supply is unregulated 110v AC.

The control information center consists of a man/auto control station with set point, bias or ratio, integrally mounted controller, with an associated miniature strip chart recorder.

Hagan's PowrMag system was designed to supplement existing systems (it is compatible with any DC electronic system) or to be designed into complete, new systems. For information, write or phone HAGAN CHEMICALS & CONTROLS, INC., Hagan Center, Pittsburgh 30, Pa. Telephone WAlnut 2-3737.



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Used in refineries throughout the world

STEWARTS AND LLOYDS fittings are manufactured to the appropriate ASTM and ASA specifications and are certified accordingly by surveyors of Lloyds Register of Shipping. These fittings are installed in refineries throughout the world.

S & L for **QUALITY**

With a hundred years' experience of tube making Stewarts and Lloyds are one of the world's leading producers.

They were the first manufacturers to be licensed by the American Petroleum Institute to apply the API monogram to oil country tubular goods.

The Company mines iron ore and produces the steel from which its pipes are manufactured. It is thus able to exercise detailed quality control during all stages from raw material to finished product.

S & L – a name synonymous with high quality.

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Wolverine Trufin Type S/T

This is Wolverine Trufin® Type S/T

Designed expressly for use in shell and tube heat exchangers, this low-finned tube has an outside to inside surface ratio of approximately 3.75 to 1. The outside diameter of the finned section is equal to the diameter of the plain ends for easy installation and replacement.

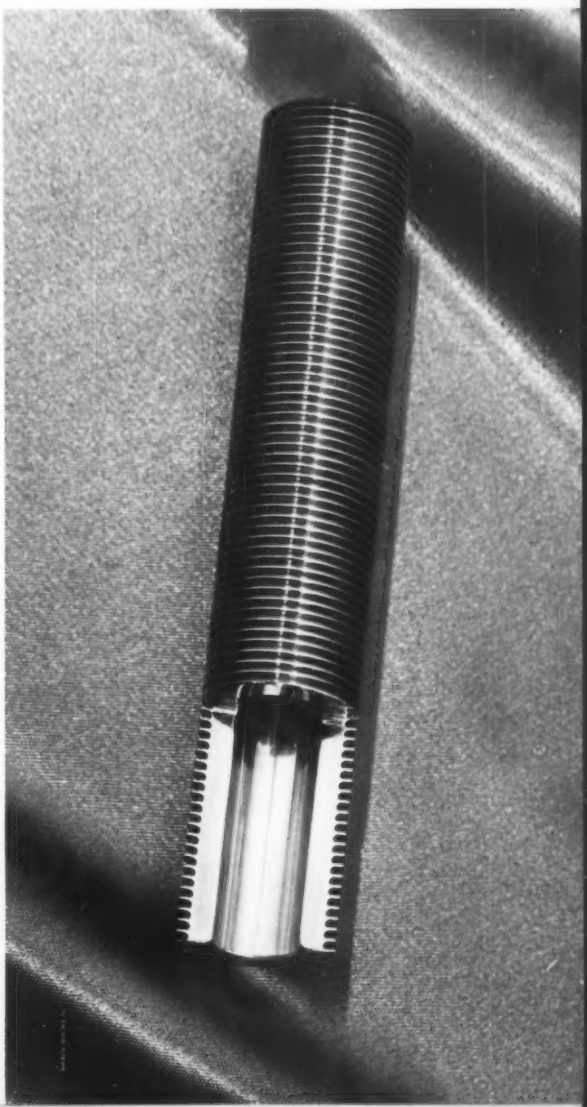
Trufin Type S/T is available in a wide range of alloys and sizes in copper, aluminum and steel and in standard fin spacings of 16 or 19 fins per inch. It can be ordered in straight length or U-bend form. It can also be readily fabricated into coils, bends, etc.

Trufin Type S/T is ideal for tube replacement in shell and tube heat exchangers or in the design of new units. In the former it can increase capacity by as much as 150 per cent. In the latter it permits a more compact unit to carry a heat load equal to a much larger unit utilizing plain tube.

This oustanding low-finned tube is also available as Trufin Type S/T Duplex—an integrally finned outer tube mechanically bonded to a conventional inner tube of any desired metal or alloy. Thus, in one tube, the user has a product with the ability to both increase heat transfer performance and withstand specific corrosive conditions.

Write for more information . . . or Ask Your Wolverine Tube Salesman—HE KNOWS.

Wolverine Trufin Type S/T Duplex



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SEE FOR YOURSELF

Take a look at the comparison chart on this page. Selected at random from Wolverine Tube's case history file, it presents dramatic proof of how integrally finned Wolverine Trufin Type S/T increases heat duty—*without increasing unit size*. In this application—the condensing of thermo-cracked straight-run gasoline from a re-run tower—capacity jumped *38%*. Also, when tubed with prime surface tube, the unit was pulled off stream every 90 days for cleaning. After tubing with Trufin Type, S/T, the tube bundle required cleaning only every eight months.

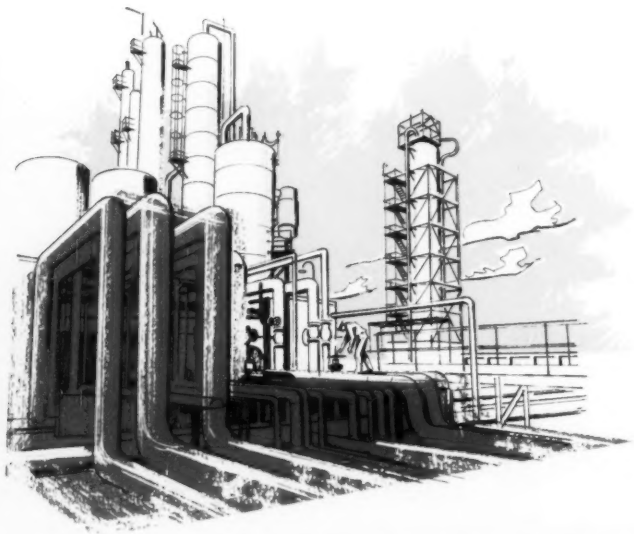
Next time you are considering revamping or retubing heat exchangers or condensers—get the Wolverine Trufin story first—see for yourself how this modern tube can help you do a better job. Write for complete information or Ask Your Wolverine Tube Salesman—He Knows.

THE SITE: A gulf coast refinery

THE WORK: Condensing thermo-cracked straight run gasoline from a re-run tower

THE UNIT: A pressure distillate overhead condenser

	PRIME SURFACE TUBE	TRUFIN—TYPE S/T
No. of tubes	500	500
Outside surface, Sq. Ft.	1522	3280
Metal	16 BWG Admiralty	16 BWG Admiralty
Tube size	¾" O.D.	¾" O.D.
Shell Side, Flow, Lbs./Hr.	19780	27350
—Temperature in	261° F.	261° F.
—Temperature out	125° F.	101° F.
Heat Load, BTU/Hr.	3,960,000	5,820,000



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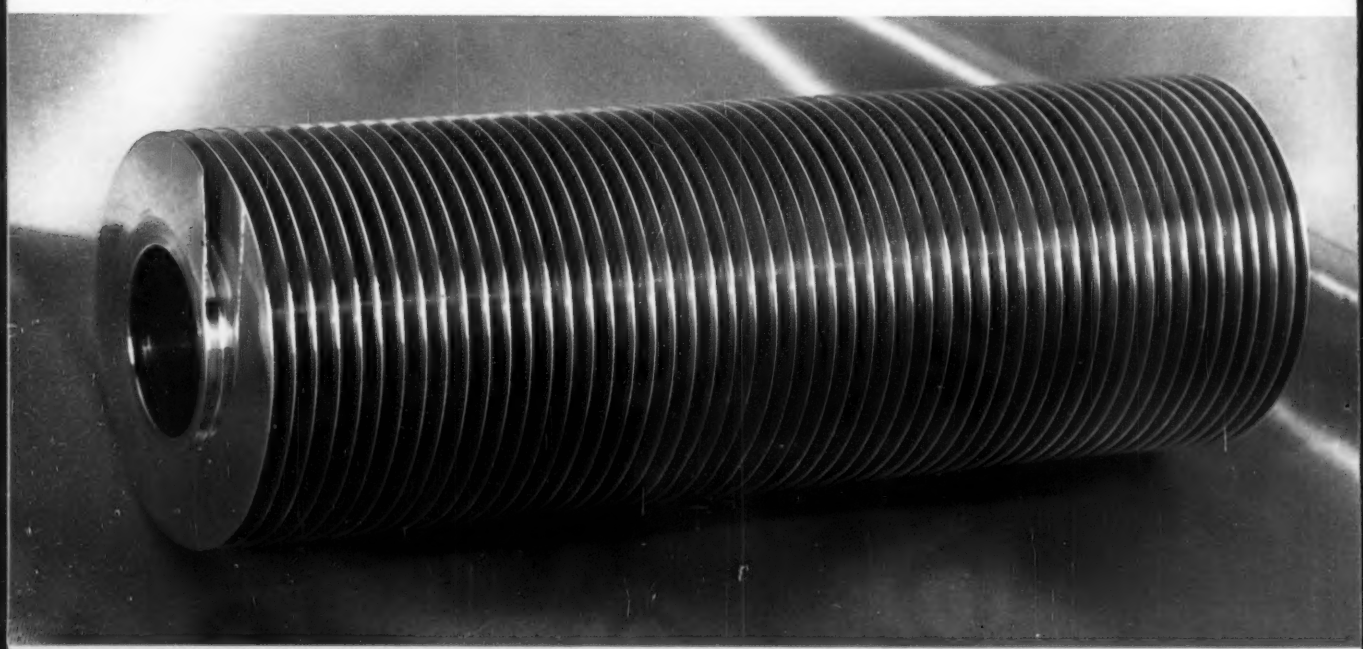
WOLVERINE TRUFIN TYPE L/C BIMETAL

And, for those applications where air cooling is advantageous, Wolverine Tube recommends Wolverine Trufin Type L/C. With its high-finned outer tube of aluminum mechanically bonded to a liner of any desired metal or alloy, Type L/C is ideal for use where water shortages or brackish or corrosive waters make liquid cooling impractical. It is finding wide use in refineries, gas plants, pipe line compressor stations, chemical plants, petro chemical plants and transformer oil coolers, etc.



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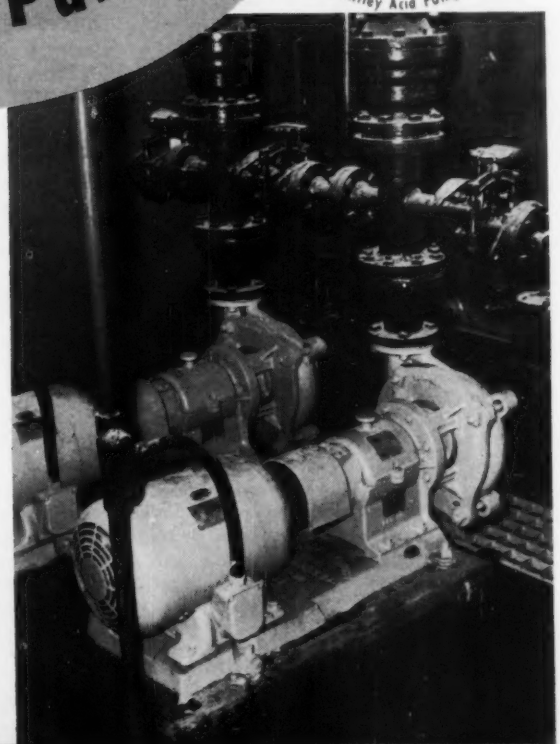

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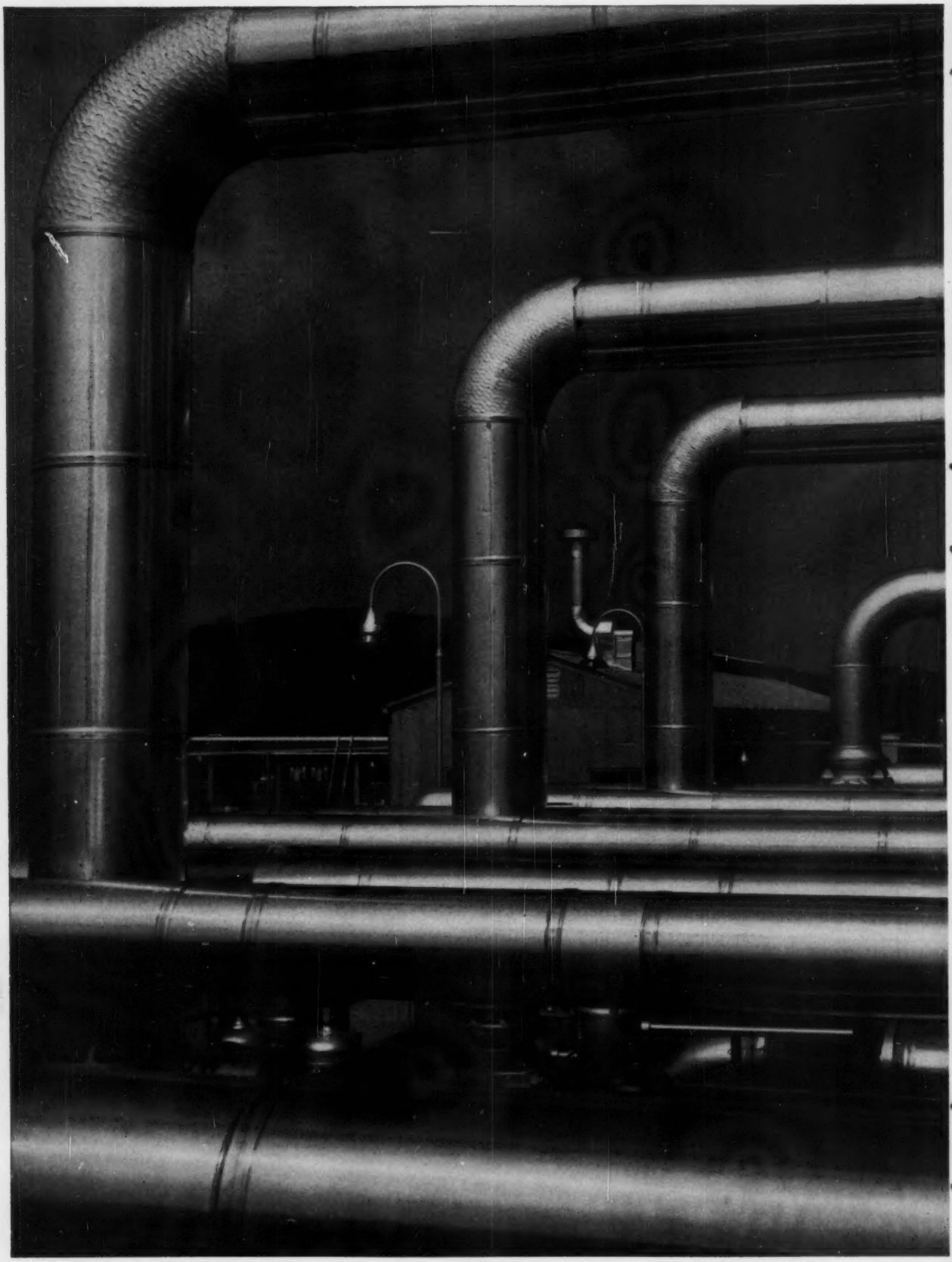
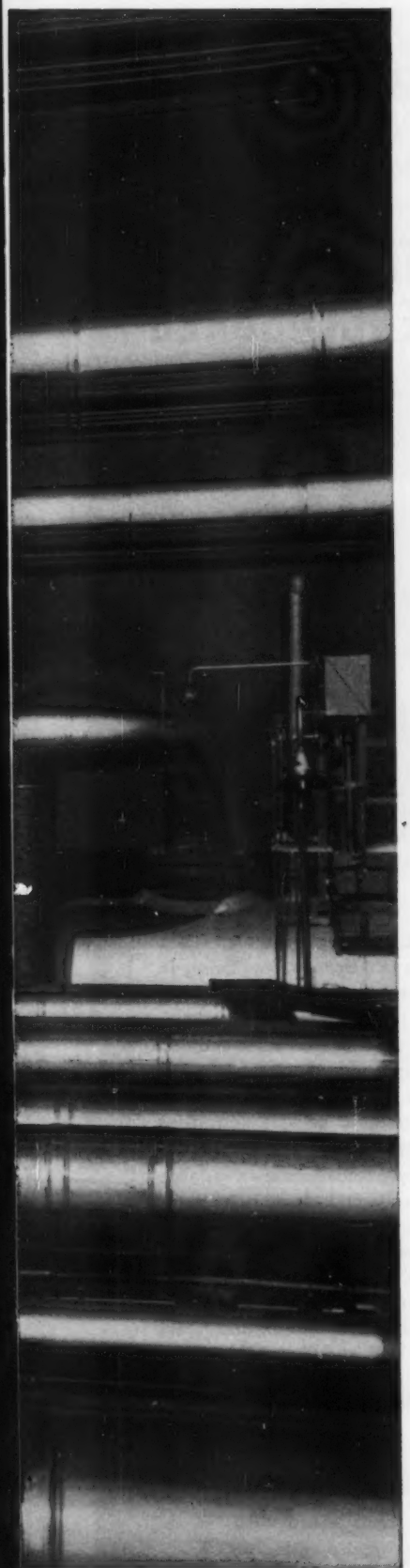


PHOTOGRAPHED AT NEW YORK STATE NATURAL GAS CORPORATION'S LEIDY COMPRESSOR STATION, TAMARACK, PA.



Installation time at Leidy Station cut 25% with prejacketed J-M METAL-ON® pipe insulation!

"ALMOST 2 MILES OF METAL-ON PROTECTS OUR OUTDOOR PIPELINES. THIS IS THE BEST–AND BEST-LOOKING–INSULATING JOB I'VE EVER SEEN,"
says head station engineer VICTOR CUMMINGS

Leidy Pool, with an ultimate storage capacity of 105.6-billion cubic feet of natural gas, is served by a compressor station incorporating almost two miles of outdoor pipelines. Both lines and equipment must be completely protected against northern Pennsylvania's violent winter storms, torrential spring rains and summer heat. Metal-On jacketing, developed by J-M, was chosen to handle this difficult job.

Metal-On is prefabricated at the factory in 36-inch lengths. Each length combines high-temperature J-M Thermobestos insulation . . . a moisture barrier . . . and a special aluminum alloy jacket. And because each length can be applied in one simple operation, erection time savings at Leidy averaged 25%! Metal-On can also be easily cut on the job with portable power or hand saws. Cutouts for hangers and supports are simple to make.

Maintenance savings can be very impressive, too. Metal-On doesn't corrode, needs no painting. The rugged jacketing, combined with a locking device that snaps closed and seals joints, will lock out weather and moisture permanently. And each section can be easily removed for trouble-shooting.

You may not have *two miles* of pipeline . . . but if you have a tough outdoor insulation problem, it will pay you to investigate J-M Metal-On. Just write to Johns-Manville, Box 14, New York 16, N. Y. In Canada: Port Credit, Ontario.

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AN INSULATION FOR EVERY COMMERCIAL AND INDUSTRIAL USE

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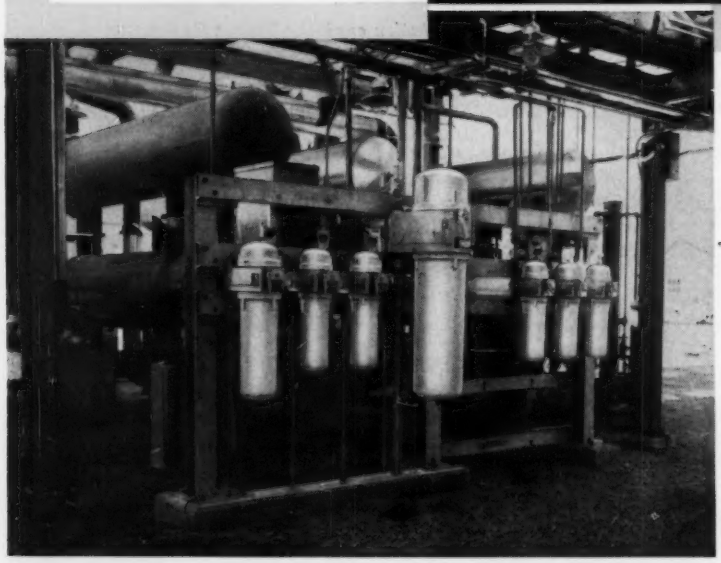
NEW RACKS FOR SPIN TOP® ENCLOSURES

FOR HAZARDOUS LOCATIONS

...you now can order Square D Spin Top enclosed starters completely wired and mounted on racks built to your specifications. Or, working through our field organization, we'll help you or your engineers design the rack. Either way, all the wiring and assembly work is done at the factory. Rack framework can be either bolted and hot-dipped galvanized or welded and painted.



INSTALLING your Spin Top rack on the job is a breeze. Just bring in the feeder connections to the bus bars, and make the outgoing power connections from starters to motors. It's as simple as that! Square D's exclusive "*slide* and hook" mounting arrangement greatly simplifies starter inspection and maintenance.

Spin Top enclosures are available in four sizes to include circuit breakers, across-the-line starters and combination starters, Size 0 through 5, reversing, non-reversing, and two-speed versions. They're built for Class I, Group C and D; and Class II, Group E, F, and G service.

***Write** for details. Square D Company, 4041 North Richards Street, Milwaukee 12, Wisconsin*

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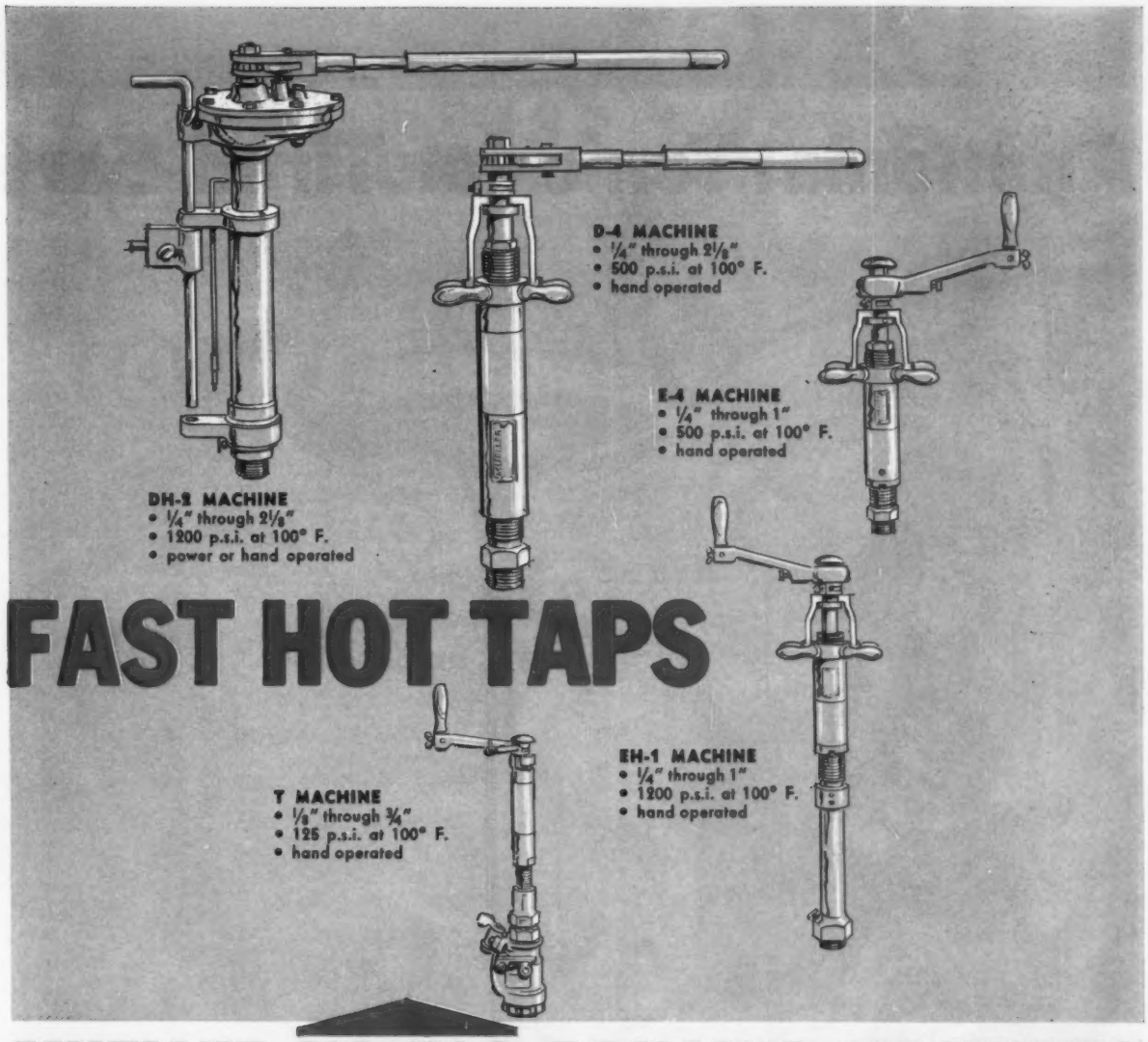

MUELLER® NO-BLO® DRILLING MACHINES

permit you to tap any size line! Small connections can be made quickly, safely, simply . . . under full line pressure . . . without loss or blowing of line fluid . . . without interrupting flow! ■■■ These dependable, "service-proven" Mueller Drilling Machines also perform all of the many No-Blo operations . . . such as, stopping-off lines or reconditioning valves and tees . . . when used with Mueller No-Blo Products in the same size range.

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another basic benefit from

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The increasing need for inexpensive yet effective fertilizers throughout the world, combined with recent improvements in Kellogg's steam-methane reforming process, make the production of ammonia from low-cost hydrocarbon sources more attractive today than ever before.

Production efficiency and economics of Kellogg-designed ammonia plants have been vastly improved. Plants built by Kellogg cost less to install and operate. Feedstock range is wider and includes not only natural gas or cracked refinery gas, but reformer off-gas, propane-butane fractions, casinghead gasoline—even naphtha, under certain circumstances.

In gas preparation, Kellogg can design for any combination of waste heat recovery, and can achieve steam balance in the plant if desired. High pressure and low pressure feed can be used as economics dictate. In gas purification, Kellogg offers the optimum combination of methods to accomplish each step—including MEA and hot carbonate to remove CO_2 and copper liquor and methanation to remove CO.

For detailed description and economic data on Kellogg's steam reforming ammonia process, write for new brochure.

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Trinidad, B.W.I.	100 T/D
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Lisbon, Portugal	180 T/D*
Cherokee, Alabama	360 T/D*

*Future

THE M. W. KELLOGG COMPANY

711 Third Avenue, New York

A subsidiary of Pullman Incorporated

Offices of other Kellogg companies are in Toronto, London, Paris, Rio de Janeiro, Caracas, Buenos Aires

RIGID

65R-TC RATCHET THREADER

with new True-Centering Workholder

Gives Better Threads Faster 4 Ways!

Here's Why:

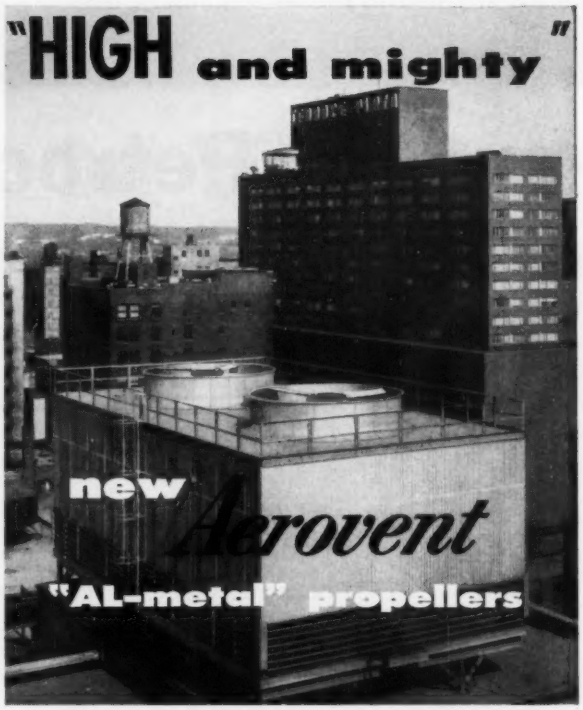
One set of dies threads 1", 1¼", 1½" and 2" pipe and conduit . . . no dies to change. • Fast-to-set, True-Centering Workholder centers dies for true threads every time • Easy adjustment for accurate "drip" threads • It's jam-proof . . . automatic kick-out—prevents jamming.

RIGID 65-RC with Cam-Type Workholder Also Available.

Call your Distributor today. For your convenience, he maintains a complete stock of RIGID Work-Saver Pipe Tools and parts!

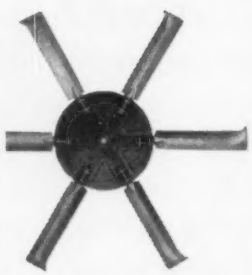
RIGID

The Ridge Tool Company • Elyria, Ohio, U.S.A.



move mountains - of AIR!

in towers and exchangers



- Sizes 14' to 18'
- 4 or 6 blades

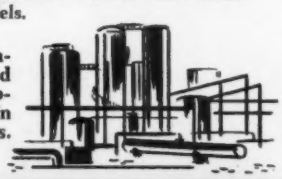
Developed originally for the petroleum industry, Aerovent Large-Diameter "Al-metal" Propellers, constructed of tough, durable aluminum alloy, move great quantities of air at high velocities, in heat exchangers and cooling towers. Pictured above are two 4-blade, 16-ft. propellers in a cooling tower installation. These mighty propellers, with adjustable-pitch "Macheta" Airfoil blades, are job-engineered to individual specifications.

Write for free Bulletin 510

DESIGNED FOR DEPENDABLE OPERATION!

Endurance tests, conducted at *3 times* normal loading prove the ability of these new large-diameter propellers to withstand severe punishment. Heavy-duty cast steel hubs offer maximum resistance to stresses. Angle settings for each operating requirement, and appropriate alternate settings, assure accurate pitch for any predetermined performance which may be required. 54" to 144" now available in Adjustable Pitch Models.

REFINERIES, pumping stations, industrial plants and commercial buildings use Aerovent "Al-metal" Propellers in major air-moving applications.

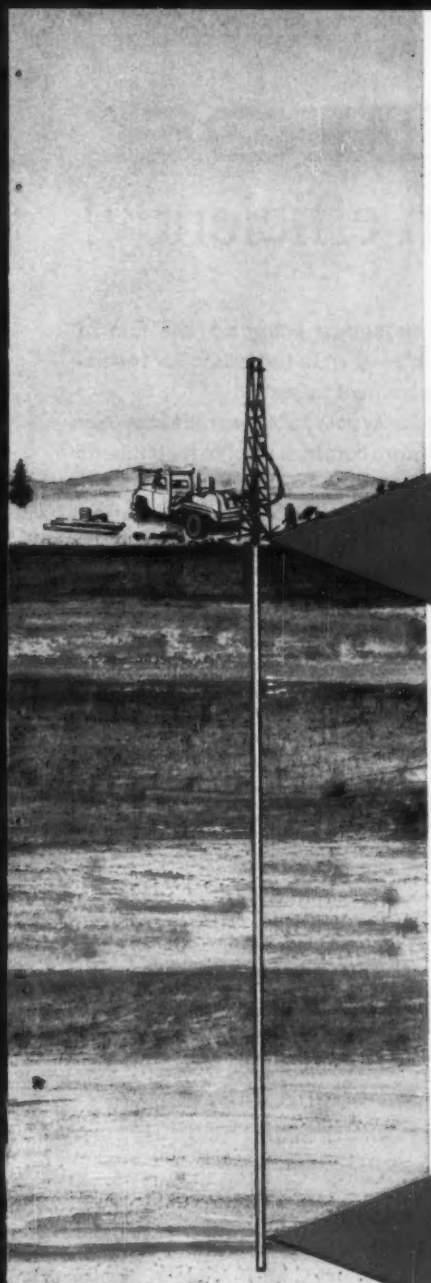


Aerovent FAN COMPANY, INC.

LARGE PROPELLER DIVISION

304 Wright Bldg.
TULSA 3, OKLA.

Main Office and Factory
PIQUA, OHIO

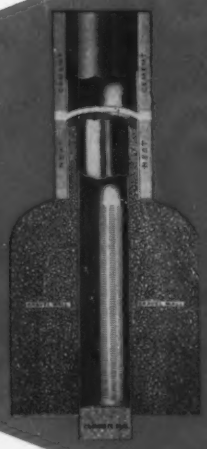


Layne
SINCE 1882

Layne Vertical Turbine Pumps are designed, engineered and manufactured by Layne in Memphis, Tennessee and nowhere else. Because pumping needs vary, there is a Layne pump for every pumping requirement—from 30 to 100,000 G.P.M. in sizes from 4 to 42 inches. Layne Pumps include Deep Well and Short Coupled (oil or water lubricated), Propeller, Mixed Flow, Regular and "In-Line" Submersible. For additional information write for bulletins 200-oil lubricated or 2C1-water lubricated.

has the only complete service that means

Water



The Layne Gravel Wall Well is an example of Layne experience, engineering and research. This gravel packing and 134 shutter screen employment affords larger screen openings, reduced friction, reduced draw down and pumping head. It increases specific capacity and makes for more effective retention of native sands. For additional information write for bulletin 900.

From top to bottom, you can depend on Layne for the most complete water service in the industry. This complete service provides undivided responsibility for the delivery of water . . . of the quality and in the quantity required. Over 75 years of *growing* service gives the skill and technical know-how which makes Layne First in the field of water. For additional information write for bulletin 10.

LAYNE OFFERS COMPLETE WATER SERVICE:

Initial Surveys • explorations • recommendations • site selection • foundation and soil-sampling • well drilling • well casing and screen • pump design, manufacture and installation • construction of water systems • maintenance and service • chemical treatment of water wells • water treatment—all backed by Layne Research.

Layne services do not replace, but coordinate with the services of consulting, plant and city engineers.

Layne SINCE 1882 COMPLETE WATER SERVICE

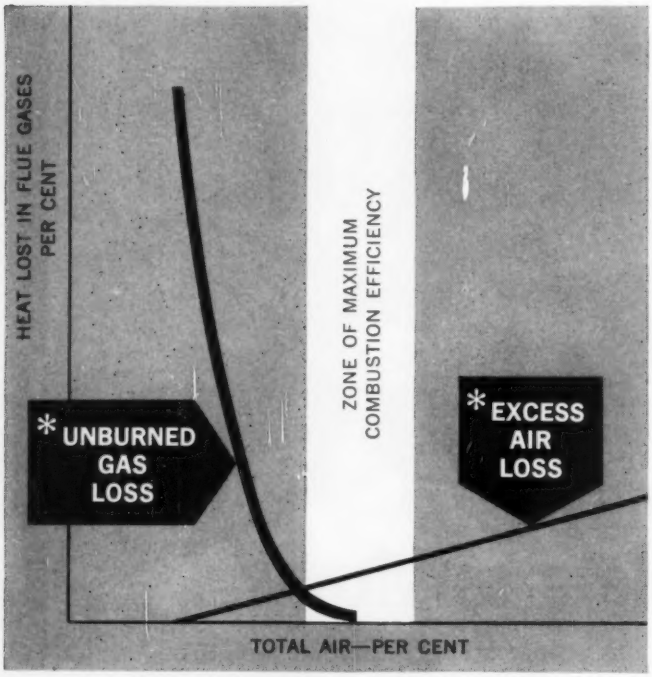
LAYNE & BOWLER, INC., MEMPHIS

General Offices and Factory, Memphis 8, Tenn.

LAYNE ASSOCIATE COMPANIES THROUGHOUT THE WORLD

SALES REPRESENTATIVES IN MAJOR CITIES

You must know BOTH* to get maximum combustion efficiency!

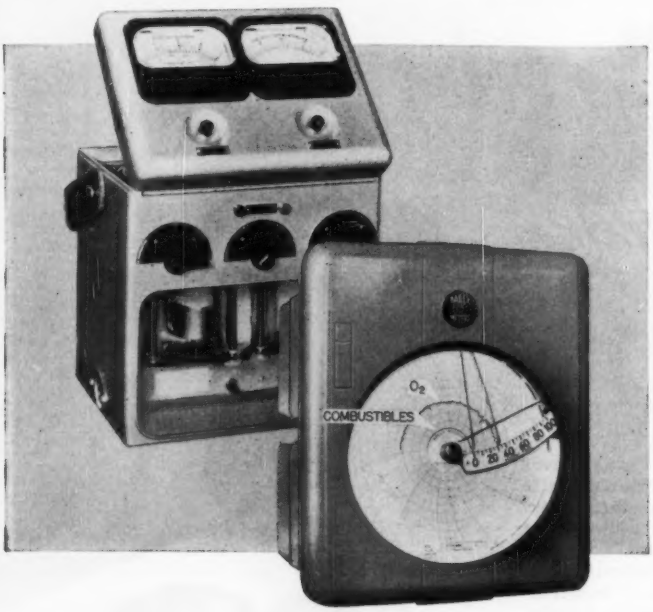

HEAT LOST IN FLUE GASES PER CENT
ZONE OF MAXIMUM COMBUSTION EFFICIENCY
* UNBURNED GAS LOSS
* EXCESS AIR LOSS
TOTAL AIR—PER CENT

How much money is going up the flue in *unburned fuel* losses? Is too much air resulting in excessive *heat* losses?

You must know *both* facts—simultaneously—to get optimum combustion. No instrument that measures only one of these interdependent factors can give you the full information you need.

Bailey offers a choice of two direct ways to maintain a continuous and simultaneous double check on these factors that determine combustion efficiency. The portable, lightweight Bailey HEAT PROVER Analyzer indicates both; the Bailey Oxygen-Combustibles Analyzer-Recorder records both on a single chart. Both instruments measure excess air, regardless of fuel or fuels being burned, and per cent of combustibles in flue gas.

Either of these Bailey instruments can save you far more than their cost in spotlighting combustion inefficiencies. Ask your Bailey engineer or write for product specifications.



2 DIRECT WAYS
to measure both combustibles and oxygen simultaneously

PORTABLE INDICATOR—Self-contained, lightweight, Bailey HEAT PROVER Analyzer enables quick, easy check on combustion conditions. Dual range dials for greater accuracy and readability.

PERMANENT RECORDER—Bailey Oxygen-Combustibles Analyzer-Recorder coordinates both records on one chart . . . is designed for permanent installation . . . helps maintain optimum ratio continuously.

* Unburned gas loss and excess air loss.

CP 112-1

Chemical and Petroleum Division

BAILEY METER COMPANY

1043 IVANHOE ROAD • CLEVELAND 10, OHIO

In Canada—Bailey Meter Company Limited, Montreal

For more data on advertised products, use Readers' Service Cards, last page.

BOILERS TO GO!

Delivered to the installation site by rail, truck or boat, shop-assembled Vogt Package Water Tube Boilers can be quickly placed in operation. After being placed from the carrier onto a simple low-cost concrete slab, a Vogt unit requires only piping, electrical and stack connections to go to work.

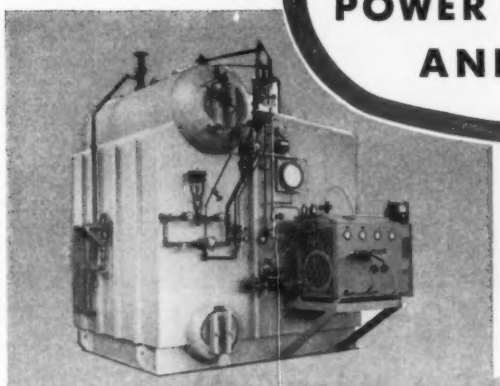
Little space is required because of their compact design and integrated firing equipment and controls.

A pressure type steel casing permits outdoor operation, if desired, eliminating the need for an expensive building.

Write for literature. Address Dept. **24A-BPR**

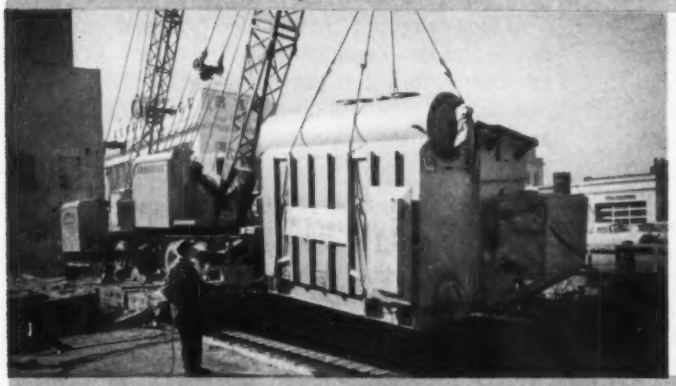
Vogt

PACKAGED BOILERS
Shop Assembled for
POWER • PROCESSING AND HEATING

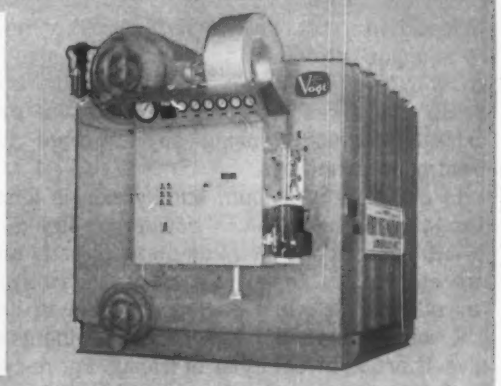


BOX PLANT — A 10,000 pounds/hour unit

HOSPITAL — Two 30,000 pounds/hour units



PRINTING PLANT — Two 20,000 pounds/hour units



OIL COMPANY — A 15,000 pounds/hour unit

For Direct Long Distance to Louisville dial: 502 ME 4-9411

Package Unit Bulletin PSG-3 available on request

HENRY VOGT MACHINE CO.
P.O. BOX 1918, LOUISVILLE 1, KENTUCKY

SALES OFFICES: Camden, N. J., Charleston, W. Va., Chicago, Cleveland, Dallas, Los Angeles, New York, St. Louis.

Sodium Borohydride Removes Trace Impurities Fast, At Low Cost!

In less than an hour you can reduce 50% of the aldehyde in your glycols without adding any significant costs to your product or process. Sodium borohydride works fast at room temperature and is extremely effective using any of three simple treatment techniques.

In pellet form, sodium borohydride is ideal for fixed-bed purification. In powder or liquid form (SWS) you can add small amounts directly to your process stream. Or, even easier, add borohydride to your glycols while packaging them in drums. The borohydride will "clean up" contaminents while glycols are in inventory or in transit. For re-cycling contaminated glycols, borohydrides are equally effective and easy to use.

At today's record-breaking low prices, if you make or use glycols—especially for plasticizers—it makes good sense for you to get facts now! Complete information, samples and on-the-spot technical service are yours for the asking!

MORE NEWS! MHI Introduces Lithium Aluminum tri-t-Butoxy Hydride! An important new hydride for the reduction of acid chlorides to aldehydes and the stereospecific reduction of steroid ketones to hydroxy derivatives. Information and 25G samples* are free.

*Shipped express collect

PIONEERS IN HYDRIDE CHEMISTRY

Metal Hydrides Incorporated

602 CONGRESS STREET, BEVERLY, MASSACHUSETTS

PLASTIC PALL RINGS

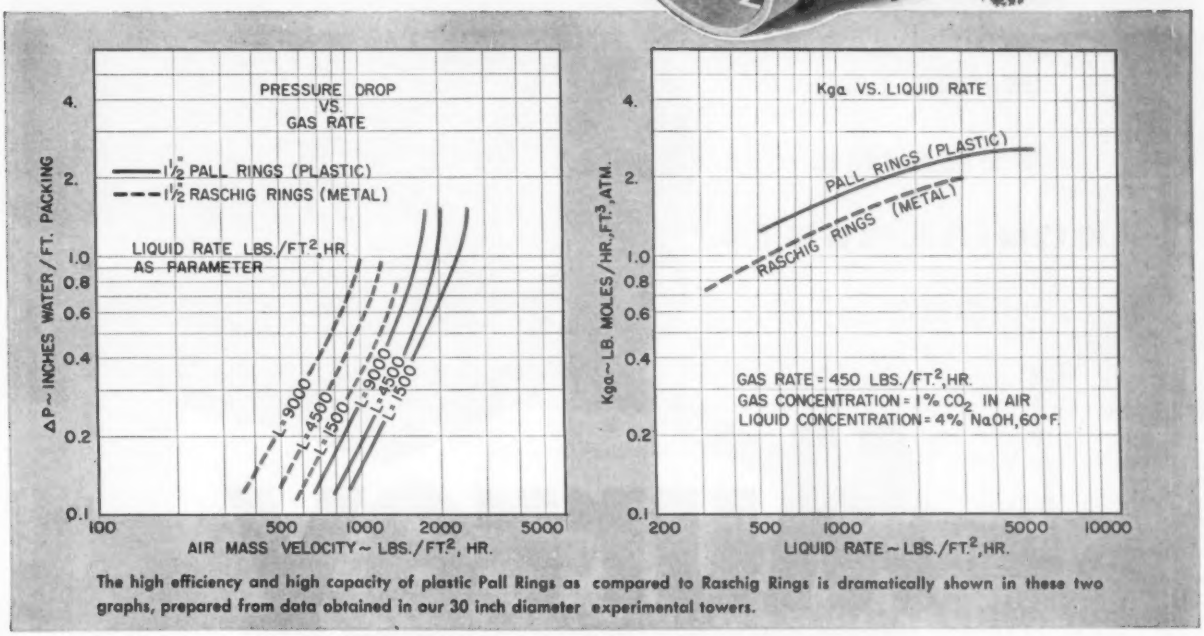
offer

high efficiency

high capacity

plus

extremely light weight


PRESSURE DROP VS. GAS RATE
1½" PALL RINGS (PLASTIC)
1½ RASCHIG RINGS (METAL)
LIQUID RATE LBS./FT.², HR. AS PARAMETER
L=9000
L=4500
L=1500
ΔP ~ INCHES WATER / FT. PACKING
AIR MASS VELOCITY ~ LBS./FT.², HR.
Kga VS. LIQUID RATE
PALL RINGS (PLASTIC)
RASCHIG RINGS (METAL)
GAS RATE = 450 LBS./FT.², HR.
GAS CONCENTRATION = 1% CO₂ IN AIR
LIQUID CONCENTRATION = 4% NaOH, 60°F.
Kga ~ LB. MOLES/HR., FT.³, ATM.
LIQUID RATE ~ LBS./FT.², HR.

The high efficiency and high capacity of plastic Pall Rings as compared to Raschig Rings is dramatically shown in these two graphs, prepared from data obtained in our 30 inch diameter experimental towers.

Weighing less than 5 lbs. per cu. ft. (as opposed to 23-27 lbs. per cubic foot in metal), plastic Pall Rings permit substantial economies in tower construction costs.

Plastic Pall Rings are injection molded in four sizes: 5/8", 1", 1½", and 2" in polypropylene (and on special order in rigid PVC or polystyrene). The sectioned wall projections, characteristic of the Pall Ring design, form a rigid cross-web in the ring for added structural strength.

Polypropylene possesses excellent resistance to strong alkalies, organic and inorganic acids including hydrofluoric acid and fluorine compounds at temperatures as high in some cases as 250°F.

ENGINEERING DATA

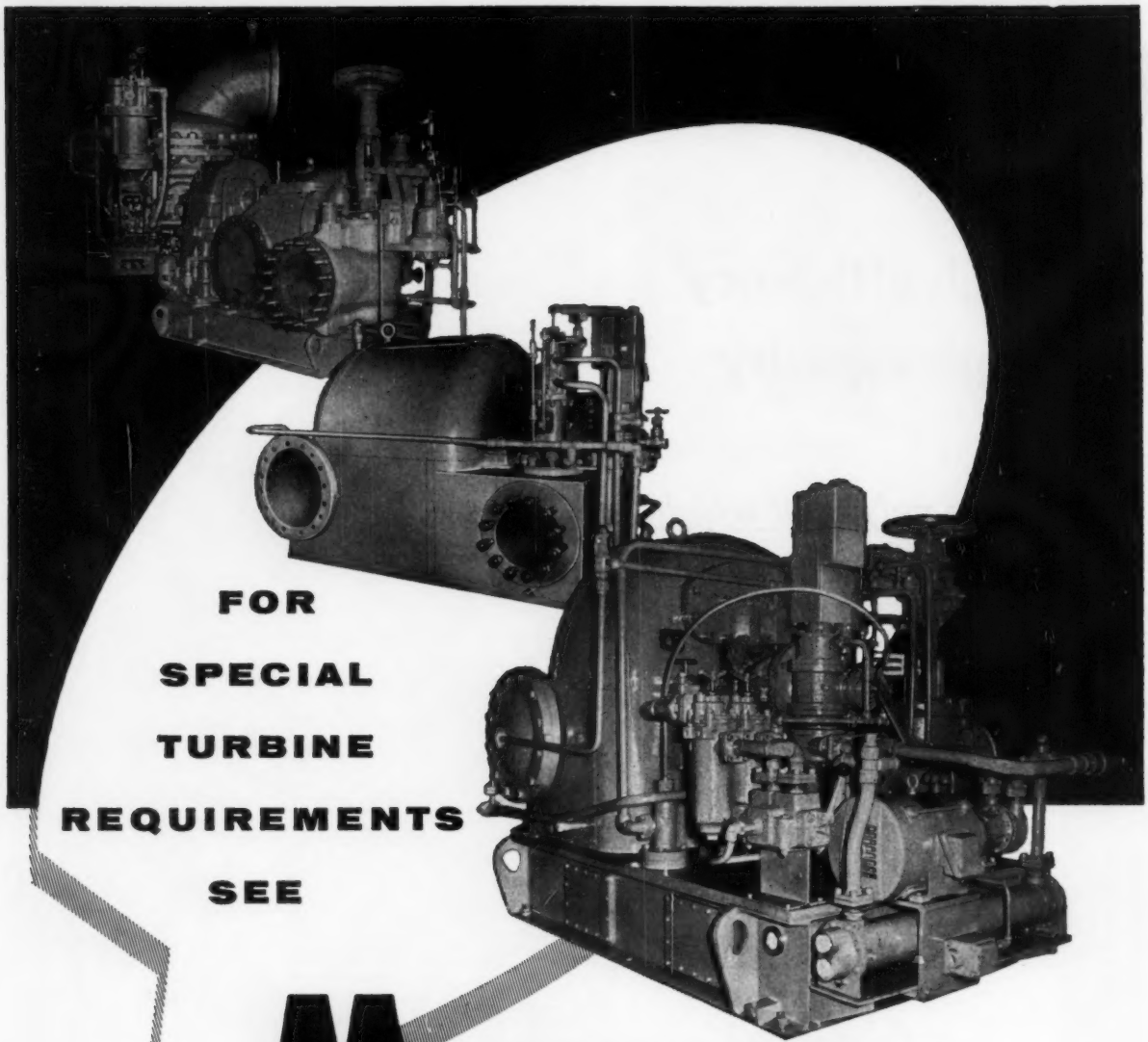
Are you on our mailing list to receive reports from our continuing engineering research program into packed tower performance? If not, a note on your letterhead will bring them promptly. Address Dept. ER., U. S. Stoneware, Akron 9, Ohio.

Process Equipment Division

U. S. STONEWARE

AKRON 9, OHIO

253-G



FOR SPECIAL TURBINE REQUIREMENTS SEE

Murray
TURBINES

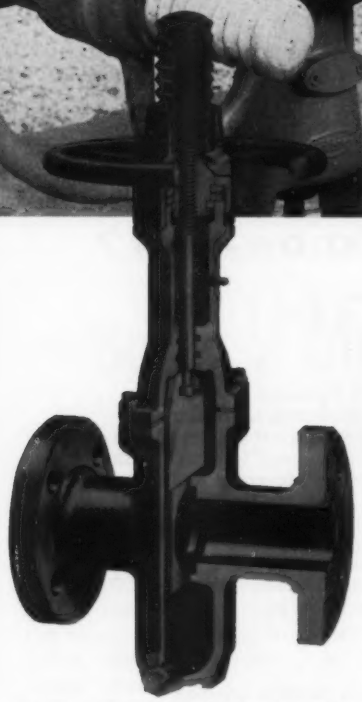
- Low Inlet Pressures
- High Back Pressures
- High Speeds
- Variable Speed Ranges
- Precise Control
- Multi-Valve Designs
- Double End Gear Drives
- Vertical Shaft Turbines

Our nearest representative will help you solve your turbine requirements. His name gladly sent on request.

MURRAY IRON WORKS COMPANY • BURLINGTON, IOWA

Builders of Steam Power Equipment for Nearly a Century

4" W-K-M Pressure Sealing Gate Valves serve as emergency shut-off for regulator handling hot P.B.C. at 440 psi, in natural gasoline plant.



Floating Seats Make Sealing Easy

Seats are specially formulated elastomer molded to a hardened steel insert. When the gate closes, line pressure forces the gate against the downstream seat making a tight seal. The upstream seat floats against the gate to maintain an upstream seal.

Emergency shut-off is a cinch with W-K-M's Pressure Sealing Gate Valve

A unique W-K-M seat design makes line pressure do most of the work — sealing the seats to positive shut-off, upstream and down. But easy operation is only part of the story.

W-K-M's new Pressure Sealing Gate Valve is ruggedly dependable. It automatically compensates for seat wear, automatically relieves excessive body pressure. And on-the-line overhaul is a simple matter.

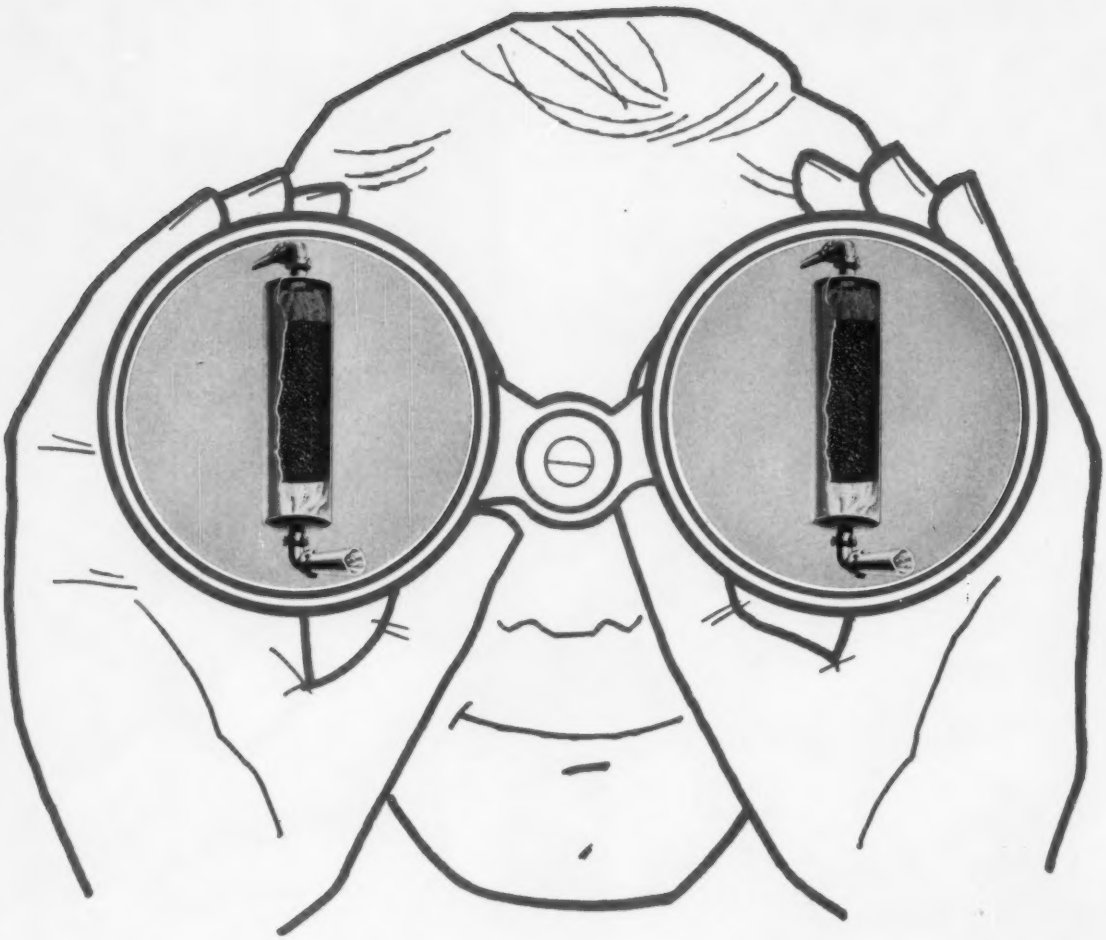
Wherever you need a smooth-operating valve for pressures to 720 psi and temperatures to 250° F., specify W-K-M's new Pressure Sealing Gate Valve. Sizes 2" through 30" — at leading distributors.

WRITE FOR CATALOG 1200

W-K-M

DIVISION OF ACF INDUSTRIES
INCORPORATED
P. O. BOX 2117, HOUSTON, TEXAS

6009



Looking for practical ADSORPTION know-how?

Call on PITTSBURGH!

IF you'd like an evaluation of your present adsorption system . . . or help in determining how continuous carbon adsorption can be effectively applied in your processing operations, call for a Pittsburgh Technical Service Representative.

His training and experience enables him to offer practical solutions to your present adsorption problems. If you're embarking on a pilot test, he's equipped to help your people set up a laboratory scale column system to demonstrate applicability and efficiency of Pittsburgh Carbons.

Versatile, coal derived Pittsburgh Granular Activated Carbons in continuous column systems have dramatically increased efficiency and lowered costs in a wide variety of adsorption processes including purification, decolorization, deodorization and catalysis, And they may be able to do the same for *you*.

Tell us about your adsorption requirements on your letterhead today or call for a Pittsburgh Technical Serviceman . . . he has adsorption "know-how."

Want More Information?
Send for this Booklet

There's a type of Pittsburgh Granular Carbon ideally suited to solve your particular adsorption problem. Write for folder describing Pittsburgh Activated Carbons in both liquid and vapor phase applications... it's free.

ACTIVATED CARBON DIVISION

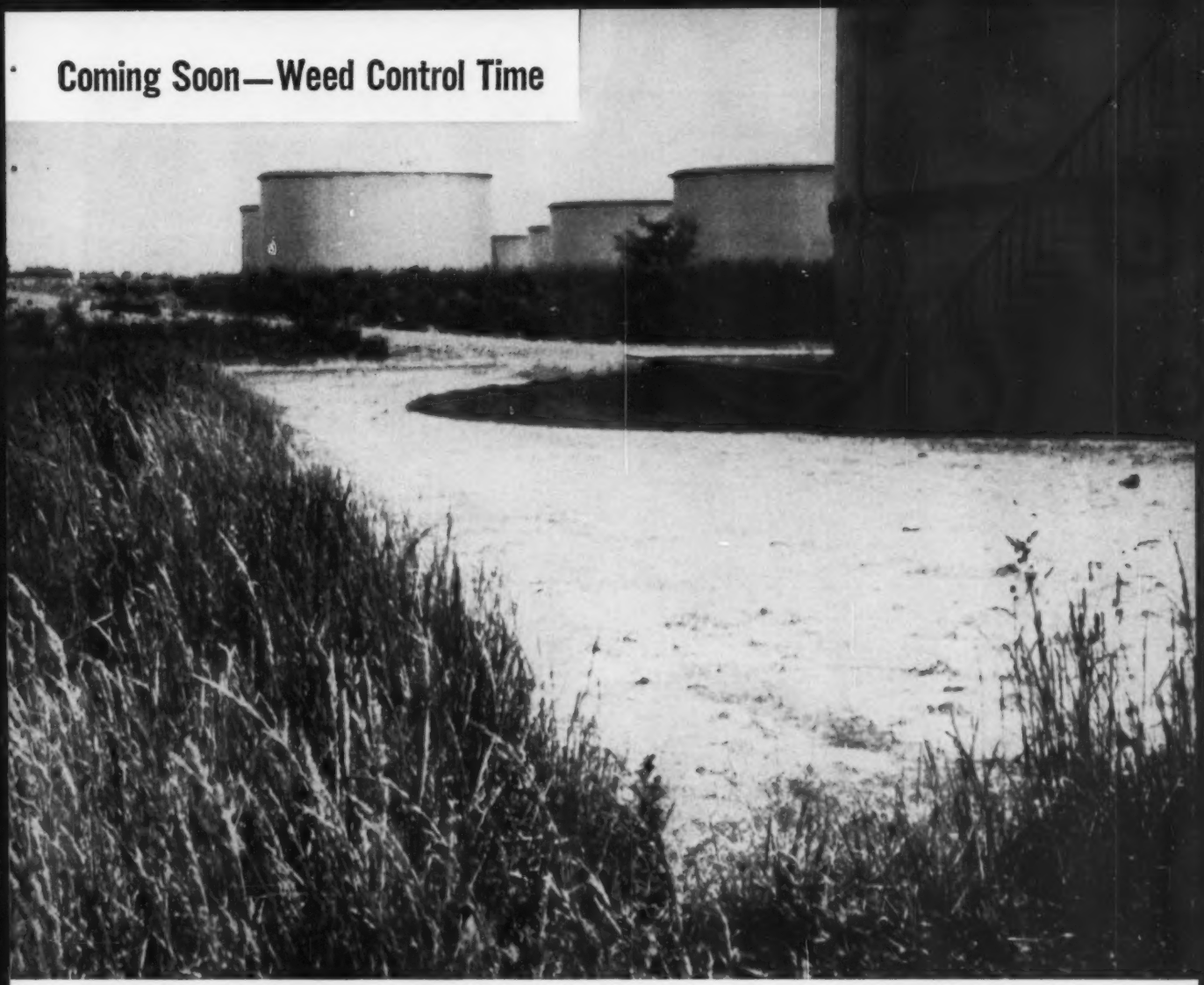
PITTSBURGH CHEMICAL CO.

GRANT BUILDING PITTSBURGH 19, PA.

A Subsidiary of PITTSBURGH COKE & CHEMICAL CO.

1737

Coming Soon—Weed Control Time



The Tidewater Oil Company obtained excellent weed control around storage tanks at their Delaware Refinery by spraying Du Pont Karmex® and Du Pont Trysben® 200. The area was sprayed in the fall of '59—the photograph taken early fall of '60.

Spray a Du Pont Weed Killer once—soon—to eliminate the hazard from fire

Best way to control weeds is to prevent them from getting established. Spray key areas with Du Pont Telvar® monuron or "Karmex" diuron weed killer—just once—right at the start of the season. That way, weeds will be killed, as soon as they sprout, by these chemicals which stay in the soil for an extended period of time to kill through the roots. In addition, spraying early gives you an entire season of freedom from the fire hazards and maintenance difficulties caused by weeds around tanks, pipelines and well areas.

Du Pont also has the answer to the problem of deep-rooted perennials with "Trysben" 200 weed killer. This new weed killer controls tough, broad-leaved perennials by acting through both roots and foliage.

All three of these Du Pont Weed Killers are easy and economical to use. They are also non-flammable and low in toxicity to humans and animals.

Why not plan this year's weed control program right now—and spray soon? A new booklet on Du Pont Weed and Brush Killers and free technical assistance is also available. Just mail the coupon.

On all chemicals follow labeling instructions and warnings carefully.

DU PONT WEED KILLERS

REG. U.S. PAT. OFF.

BETTER THINGS FOR BETTER LIVING . . . THROUGH CHEMISTRY

E. I. du Pont de Nemours & Co. (Inc.)
Industrial & Biochemicals Department
Room 2543-N, Wilmington 98, Delaware

☐ Please send me your new booklet on Du Pont Weed Killers. ☐ I would like to have assistance in setting up an effective weed control program.

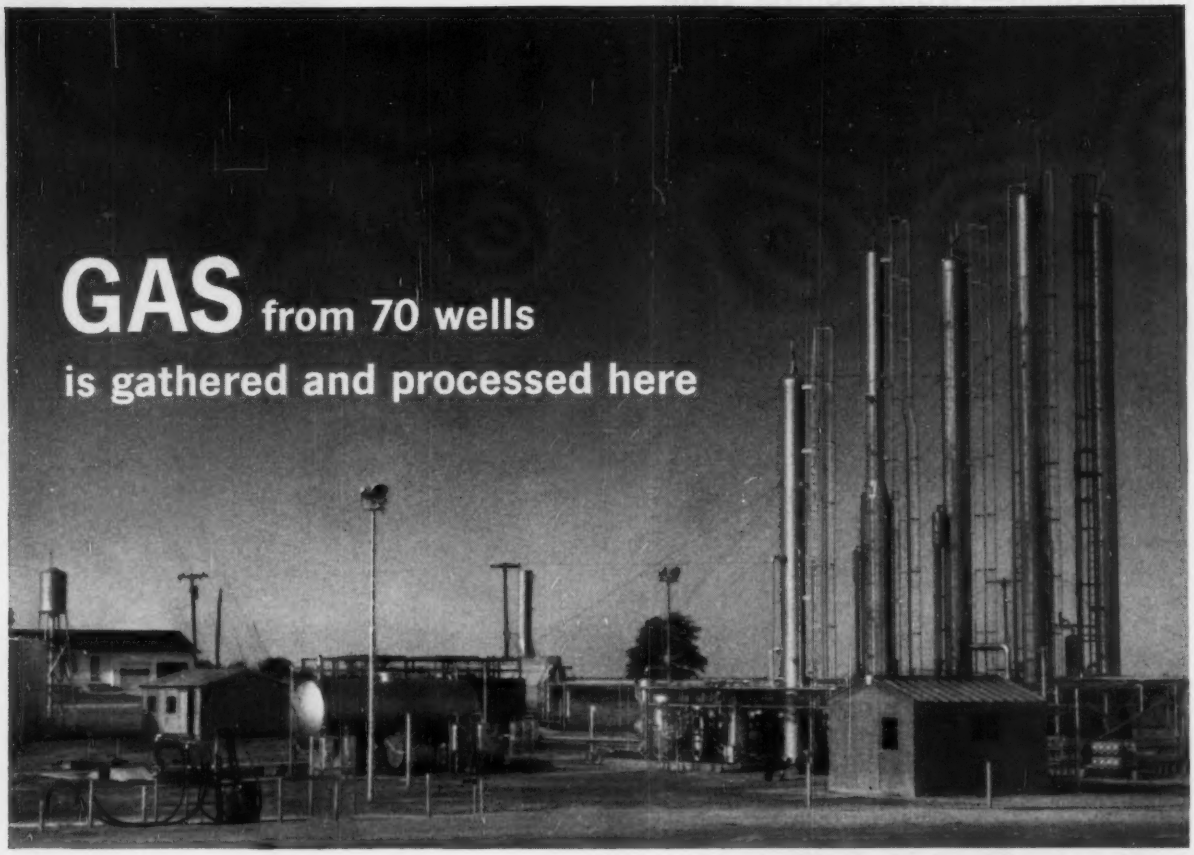
Name_____

Title or Position_____

Firm_____

Address_____

City_____ Zone___ State_____



"JENKINS valves give us the dependable performance our operations demand."

— states Kerr-McGee Oil Industries, Inc., Oklahoma gas producer

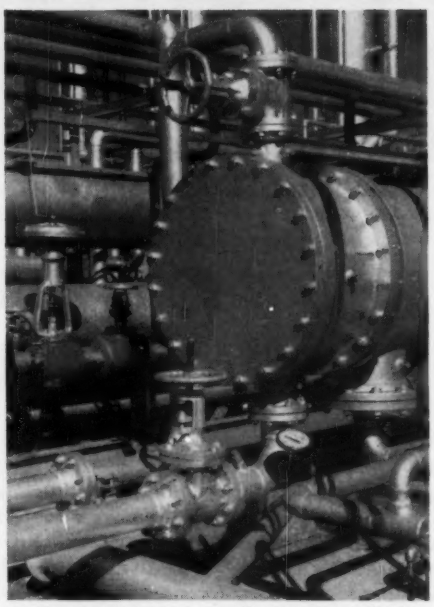
How Kerr-McGee's field processing plant in Lincoln County, Oklahoma, gathers and extracts valuable hydrocarbons from gas before delivering it to the consumer is an interesting story, briefly told below. But you need not know the process to appreciate the fact that maximum reliability in valves is a "must".

The valves that assure Kerr-McGee of dependable, trouble-free performance bear the same name as that written on piping layouts of critical jobs of all kinds for almost a century. Experienced engineers, contractors and operating executives know that "JENKINS" stands for an extra-measure of quality. They know it is the best guarantee of long, trouble-free service. There's no extra cost attached to this specification for extra quality, so you can use it for any job. Jenkins Bros., 100 Park Ave., New York 17.

HOW THE GAS PROCESSING PLANT WORKS...

Because it is a vapor at low pressure, gas is first compressed and injected into the bottom of a tall tower, called an absorber; oil is injected at the top. As the oil goes down, the gas goes up . . . the gas products are absorbed by the oil. The gas enriched oil is then processed to remove valuable light hydrocarbons.

Sold Through Leading Distributors Everywhere

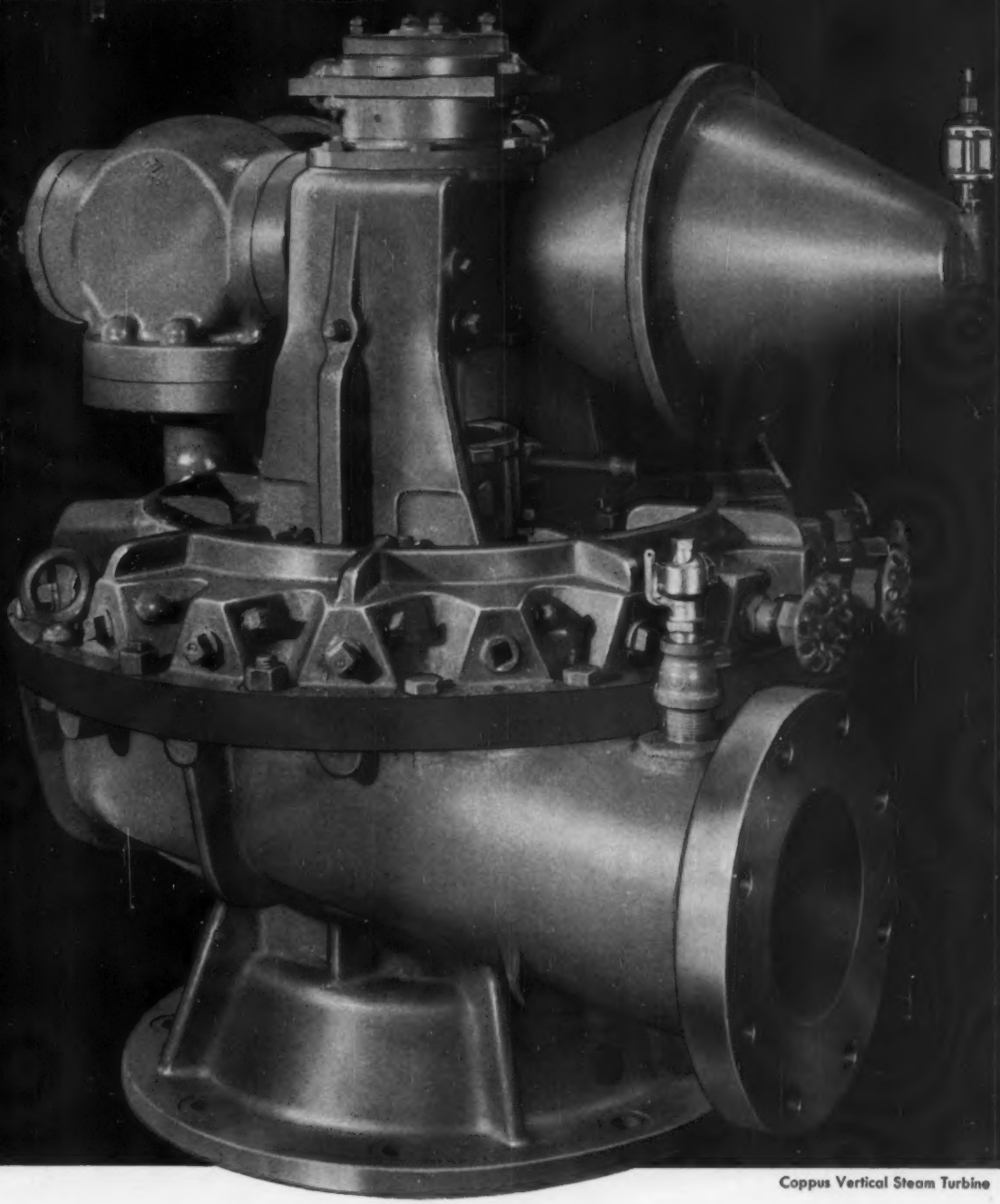


Jenkins Gate Valves on lean oil cooler to the absorber

JENKINS
LOOK FOR THE JENKINS DIAMOND
VALVES
JENKINS SINCE 1864 Jenkins Bros

For more data on advertised products, use Readers' Service Cards, last page.

COPPUS BLUE RIBBON PRODUCTS



Coppus Vertical Steam Turbine

THE MARK OF QUALITY — There's no better test of a turbine's quality than performance. And the new, ruggedly designed, power-packed Coppus Turbines pass all performance tests with top honors! Small wonder. Coppus quality is literally designed and built into them. Their super stamina is the end-product of painstaking craftsmanship, finest materials and methods, thorough testing and control. Each truly deserves its Blue Ribbon . . . assurance of *complete* reliability.

Typical Coppus Blue Ribbon features are: *totally enclosed governor . . . totally enclosed and independently operated safety trip . . . easily replaceable packing and bearings . . . multiple steam nozzle control . . . brake rim for added safety . . . wide bucket "L" type wheel (optional) for minimum water rate.* You get higher efficiency operation . . . less down time . . . lower maintenance costs.

Coppus Turbines are built to customers' specifications, including API and NEMA standards. Send for Catalog 200. Get complete details on Coppus Turbines. Sizes from 1 HP to 250 HP. Write COPPUS ENGINEERING CORPORATION, 413 Park Avenue, Worcester, Mass. Sales Offices in *Thomas' Register*.

COPPUS
STEAM TURBINES

YOU GET *MORE VALUE*

FOR *LESS COST*

CC108

Versatility of the Conoflow LB valve makes it suitable for any control service—easy or tough. Write for literature today or contact your local Conoflow representative (in all principal cities) for prices.

CONOFLOW SUBSIDIARY WALWORTH

CONOFLOW CORPORATION

FOREMOST IN FINAL CONTROL ELEMENTS

2100 ARCH STREET, PHILADELPHIA 3, PA.

For more data on advertised products, use Readers' Service Cards, last page.

Pennsalt service helps you cash in on HYDROFLUORIC ACID alkylation

The striking savings you can get when you alkylate with hydrofluoric acid are a matter of record. And Pennsalt's long, specialized experience with AHF can help you take advantage of these savings. We'll show you how to handle, store and use Pennsalt AHF safely and confidently . . . advise you on valves, pumps, piping and materials of construction . . . help you with employee training programs . . . give you personalized technical assistance tailored to your needs. Ask your Pennsalt representative, or write for full information. Industrial Chemicals Division, PENNSALT CHEMICALS CORPORATION, Three Penn Center, Philadelphia 2, Pa.

- Lower catalyst cost
- Shorter reaction time
- Faster catalyst settling
- Reduced acid inventory
- Lower cooling expense
- Minimum spent acid problems
- Minimum side reaction products

New HF Handling and Data Book. Includes text, drawings, graphs, tables, photos. Write for Bulletin S-148.

See our complete listing in Chemical Materials Catalog

Industrial Chemicals Division

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PHILADELPHIA • PITTSBURGH • ST. LOUIS • APPLETON
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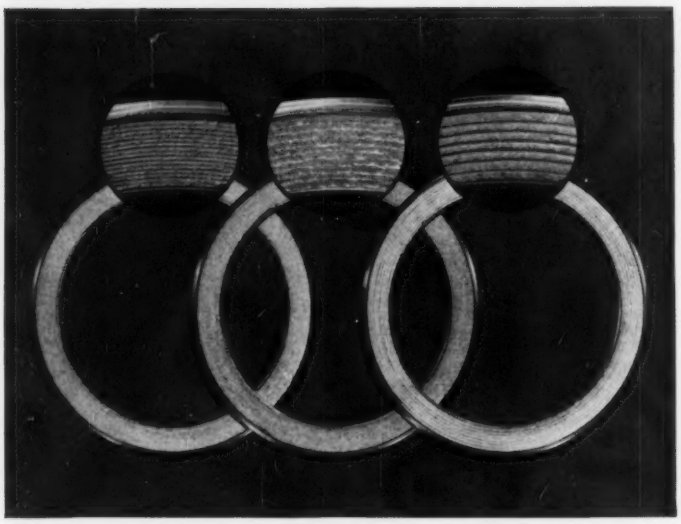
INDUSTRIAL QUÍMICA PENNSALT, MEXICO CITY

Pennsalt Chemicals
ESTABLISHED 1850

For more data on advertised products, use Readers' Service Cards, last page.

ENGINEERED GASKETS for Plant Maintenance



Exacting control of gasket density is obtained by varying the number of metal plies and filler material to seal a specific pressure.

Controlled density is the reason why Garlock *Guardian Gaskets offer you unusual sealing ability.** A series of V-shaped metal plies alternated with layers of filler form the "body" of GUARDIAN spiral-wound gaskets. The proper selected thickness of filler material and preformed metal, the number of laminations of filler and metal and the correct tension of filler and metal while being formed into a gasket are factors engineered to achieve the proper gasket density.

This controlled density—combined with the special V-shaped metal plies—allows the gasket to "breathe." Thus, a tight seal is effected at all times despite equipment or line expansion and contraction. In no other type of gasket is it possible to vary the compressibility to meet different pressure and bolt load requirements.

Complete range of sizes, and shapes and wide temperature range is another reason for specifying Garlock GUARDIAN Gaskets . . . 1/16" thickness up to 6", 1/8" up to 30", .175" up to 60" and 1/4" thick up to 60" depending on flange width. For temperatures up to +1900°F. with ceramic filler material.

Type CR GUARDIAN Gaskets are furnished with a cadmium plated centering ring for corrosion resistance and prolonged shelf life. Centering ring also is marked with the pressure series —assuring application of correct gasket density for specific pressure.

Convenient local stocks of most standard sizes are maintained at Camden, New Jersey, Cleveland, Ohio, Houston, Texas and San Francisco, California, for quick delivery.

GARLOCK

Find out more from your Garlock representative at the nearest of the 26 Garlock sales offices throughout the U. S. and Canada, or write for catalog AD-176, Garlock Inc., Palmyra, N. Y.
Canadian Div.: Garlock of Canada Ltd.
Plastics Div.: United States Gasket Co.

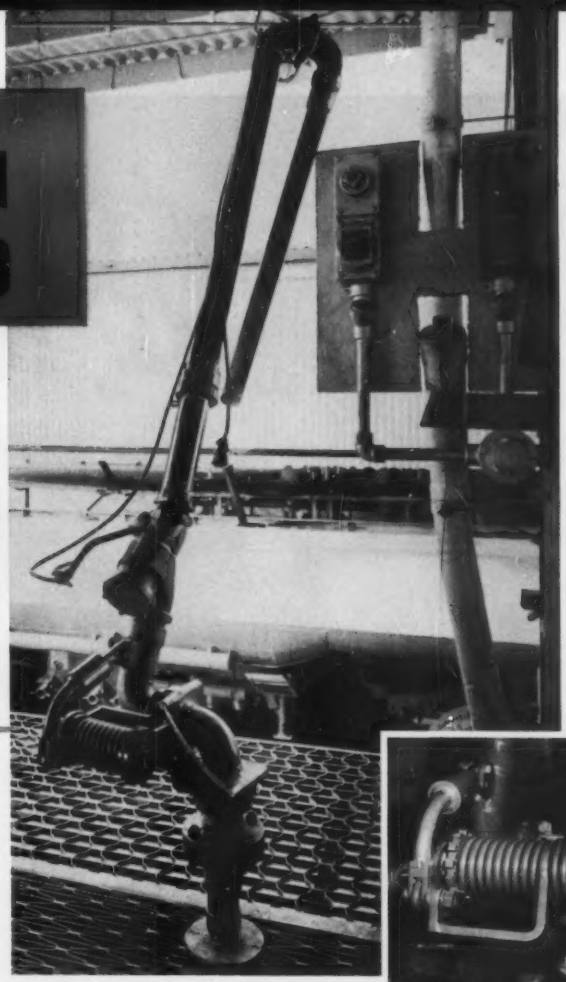
Order from the Garlock 2,000... two thousand different styles of Packings, Gaskets, Seals, Molded and Extruded Rubber, Plastic Products.

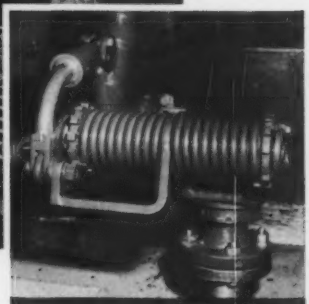
*Registered Trademark

IT'S *NEW* FROM CONTINENTAL-EMSCO

SPRING-BALANCED *LOADING ARM*

. . for faster, safer loading of petroleum and chemical products





DOUBLE SPRING ASSEMBLIES are available on standard units to balance heavier loads.

EXCLUSIVE SNUBBER SPRING . . . enclosed in the housing above main spring . . . absorbs arm's upward thrust.

You can see how Continental-Emsco's use of a torsion-type spring makes this loading arm compact and streamlined. Weights, pulleys, cables are eliminated, so platforms are cleaner . . more modern looking . . safer for personnel.

These thoroughly field proven, extremely rugged units incorporate heavy-duty bearings which are widely spaced to withstand continual loading and sudden, severe shocks. Riser joints are made of steel to take the punishment of the hardest loading operations. Packing can be replaced without removing joint from the arm or disturbing bearings, and Buna "N", Teflon or Viton "A" packing is available for handling a wide variety of products . . assuring the lowest possible cost.

Standard models are available in 3″ or 4″ sizes in either rigid or telescoping designs with flanged or threaded riser connections. Six standard models provide the variety of designs necessary to replace old arms or to equip new platforms at minimum cost. Custom-designed arms can be furnished to fit any special installation. Modernize your platform with competitively priced Continental-Emsco spring-balanced loading arms.

Write, wire or call today for complete information.

CONTINENTAL-EMSCO COMPANY
a Division of The Youngstown Sheet and Tube Company

Industrial Products Division • P. O. Box 359 • Dallas 21, Texas

SJ006

Brand-New Sphere of Activity!

Here is a MACROPORT* "A" aluminum oxide sphere — Norton Company's newest development in catalyst carriers shown enlarged. Note its extremely porous structure, specifically designed to promote *faster, more precisely controlled* gaseous reactions. Pores are much larger than those in other Norton catalyst carriers, permitting gases to enter and diffuse readily, yet providing sufficient restriction for optimum control.

MACROPORT "A" catalyst carriers are currently available as spheres, pellets, and aggregate of fused aluminum oxide in the same price ranges as standard Norton carriers. A research program is now underway in the Norton laboratories to develop MACROPORT carriers in other materials.

For better yields from *your* reactors and improved process economy, get complete details on Norton MACROPORT "A" carriers. Write NORTON COMPANY, Refractories Division, 462 New Bond Street, Worcester 6, Massachusetts.

TYPICAL PHYSICAL PROPERTIES

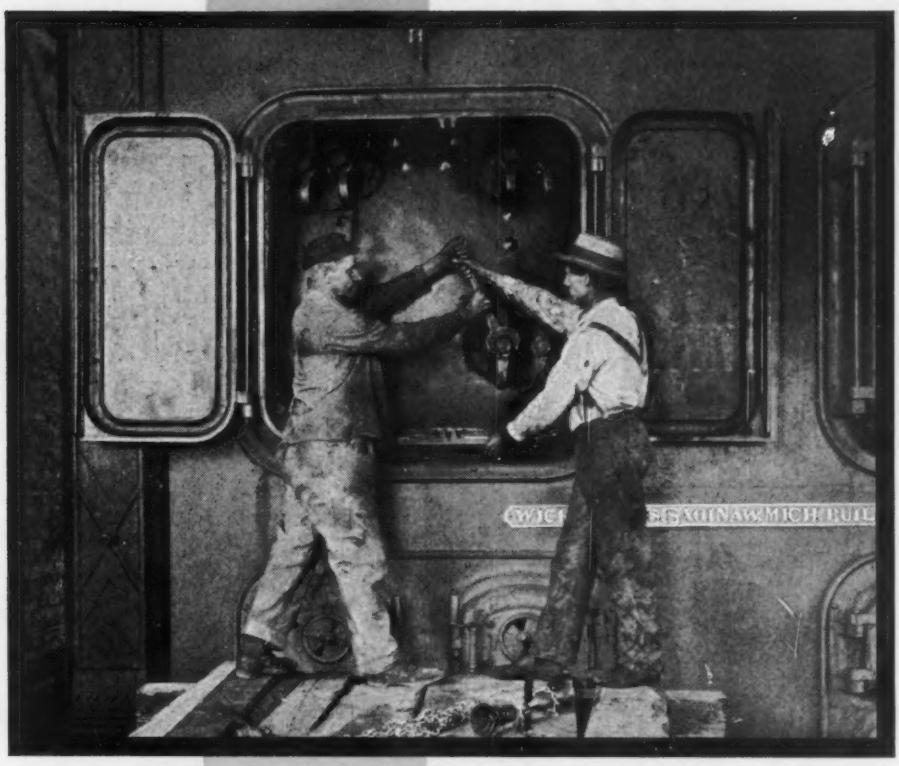
	MACROPORT "A" 5/16"-½" Spheres	Aggregate (3-5 Mesh)
Apparent Porosity %	44-48	40-44
H_2O Absorption %	22-26	18-22
App. Sp. Gravity g/cc	3.4-3.6	3.4-3.6
Bulk Density g/cc	1.8-2.0	2.0-2.2
Packing Density lbs./ft³	63-67	68-72
Pore Dia. Range	50-200 Microns	50-200 Microns

*Trademark

NORTON
REFRACTORIES
Engineered... Rx ...Prescribed

75 years of . . . **Making better products . . . to make your products better**

NORTON PRODUCTS: Abrasives • Grinding Wheels • Machine Tools • Refractories • Electro-Chemicals — **BEHR-MANNING DIVISION:** Coated Abrasives • Sharpening Stones • Pressure-Sensitive Tapes

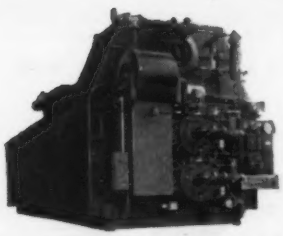


This boiler, built by Wickes Boiler Co. in 1875, operated satisfactorily for the next 31 years.

When buying modern Boiler Equipment it pays to deal with an *EXPERIENCED MANUFACTURER*

There is no substitute for experience. From the first pioneering days in boiler manufacture, years before the boiler pictured above was built, Wickes Boiler Co. has continued to be a world leader in the development of economical, efficient and dependable steam generators. Today, Wickes builds steam generators in sizes to 500,000 lbs. of steam per hour, for high or low steam pressures and temperatures and for all types of fuels and firing methods.

A Wickes steam generator, custom engineered to exact generating requirements, is built to the highest standards of workmanship, backed by over a century of boiler making experience.



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THE WICKES CORPORATION · ESTABLISHED 1854 ·

WICKES

175

WICKES BOILER CO. DIVISION OF THE WICKES CORPORATION, SAGINAW 18, MICHIGAN

For more data on advertised products, use Readers' Service Cards, last page.

FOR TITAN MISSILE BASES...

1800 EXPANSION JOINTS OF STAINLESS STEEL

Air Force Titan missile bases require many miles of stainless steel LOX piping. To protect these piping complexes from thermal changes and shock conditions, special stainless steel expansion joints —1800 of them—were required.

Adsco built these special expansion joints, taking them carefully through design, forming, welding, and assembly. The expansion joints were cycle-tested with liquid nitrogen at -297° F. and cleaned. The Corps of Engineers inspected each one under black light and each joint was hermetically-sealed. System cleanliness limits were 25 parts per million —150 micron particles.

Knowledge and experience such as this could be of help to you in your expansion joint work. Call on Adsco!

ADSCO DIVISION
20 MILBURN STREET
BUFFALO 12, NEW YORK

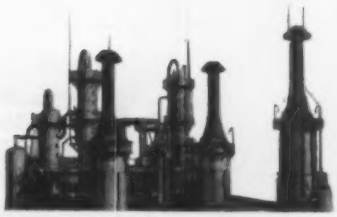
YUBA

YUBA CONSOLIDATED INDUSTRIES, INC.

For more data on advertised products, use Readers' Service Cards, last page.

JGC CREATIVITY.... for better plants

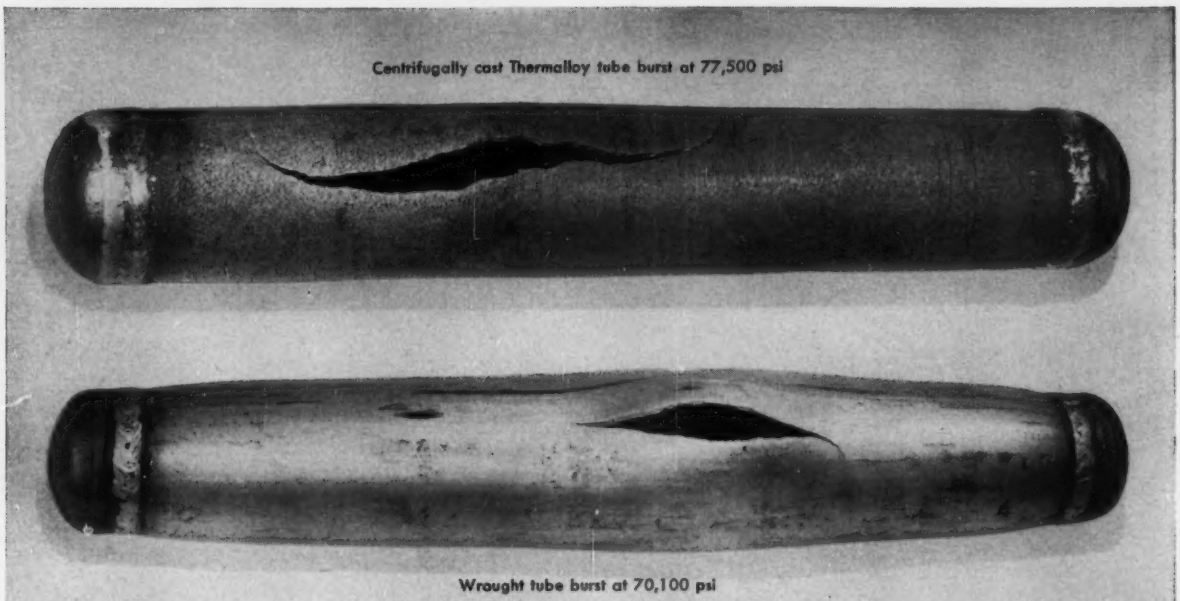
At JGC, for 30 years the tools and talents of individual research, designing, engineering and construction specialists have been expertly teamed to build the very best petroleum and petro-chemical plants .....all in one favorable contract. Your inquiries are welcomed.



Engineers & Constructors

JGC **JAPAN GASOLINE CO., LTD.**

New Otemachi Bldg., Tokyo, Japan



Centrifugally cast Thermalloy tube burst at 77,500 psi

Wrought tube burst at 70,100 psi

Burst tests prove 7,400 psi superiority of centrifugally cast Thermalloy® tubes

Hydrostatic pressure tests by Electro-Alloys established the rupture of a centrifugally cast Thermalloy tube section at 77,500 psi. Under the same conditions, wrought tubes of comparable section and analysis burst at 70,100 psi. These tests were conducted at room temperatures. Tensile tests show this strength margin increases substantially at the higher operating temperatures (1500° — 1800° F). The Thermalloy tube was tested *as cast*— without machining the inside or outside diameter. For further data, call your representative, or write Electro-Alloys Division, 3023 Taylor Street, Elyria, Ohio.

AMERICAN Brake Shoe COMPANY

ELECTRO-ALLOYS DIVISION • Elyria, Ohio

Saves up to 23% over cost of steel valves!

Fisher nodular iron control valves

Nodular Cast (ductile) Iron valve bodies have higher yield strength than steel ● Ability to resist mechanical shock compares favorably to steel ● NCI valves have been tested at three times their rated pressure ● Corrosion resistance is as good, and generally better, than cast iron or carbon steel ● Effective in temperature ranges of −20°F. to +650°F. and pressures up to 1,000 psi. ● Shock or impact characteristics are comparable to steel ● *For more information, send for Technical Paper TM-5.* Fisher Governor Company, Marshalltown, Iowa. Plants in Woodstock, Ont., Rochester, England. Butterfly Valve Division: Continental Equipment Co., Coraopolis, Pa.

NCI VALVE BODY SPECIFICATIONS

Body Styles—Double or single port globe bodies • **Body Sizes**—½ through 12" • **End Connections**—Screwed, ASA raised face or RTJ 150 to 600 psi flanges • **Plug Style**—Top and Bottom guided, V-Pup or Throttle Plug • **Pressure**—Temperature Ratings—Pressure 80% of corresponding steel flanges at a given temperature with maximum pressure up to 1,000 psi and maximum temperature 650°F. **Minimum Temperature**—Minus 20°F.

COMPARISON OF MECHANICAL PROPERTIES

	Cast Iron ASTM A126-B	Nodular Iron ASTM A395	Cast Steel ASTM A216-WCB
Tensile Strength, PSI	31,000 Min.	60,000 Min.	70,000 Min.
Yield Strength, PSI	———	45,000* Min.	36,000 Min.
Elongation, % in 2" Gage Length	NIL	15	22
Modulus of Elasticity, PSI	12—20x10⁶	24x10⁶	30x10⁶

*0.2% Offset

If it flows through pipe anywhere in the world ...chances are it's controlled by.....

FISHER® Controls SINCE 1880

For more data on advertised products, use Readers' Service Cards, last page.

WE KEEP THE "BIG CATS" CRACKING

The "Big Cats," those steel behemoths that work wonders with the gasoline molecule, have a wild streak in them. Unless kept under control they can whip up a storm of flying catalyst dust that raises havoc with the operation and brings the Air Pollution Control people running.

To avoid this embarrassing and economically hazardous situation, refiners install our high efficiency SDC Duclones and Trickle Valves. They save money . . . improve performance . . . and in general do an admirable job. They snare each flying catalyst particle and plummet it back into the fluid bed to perform the miraculous task of catalytic cracking.

Is it any wonder that Duclones were used in two large refineries which set records for continuous on-stream service.

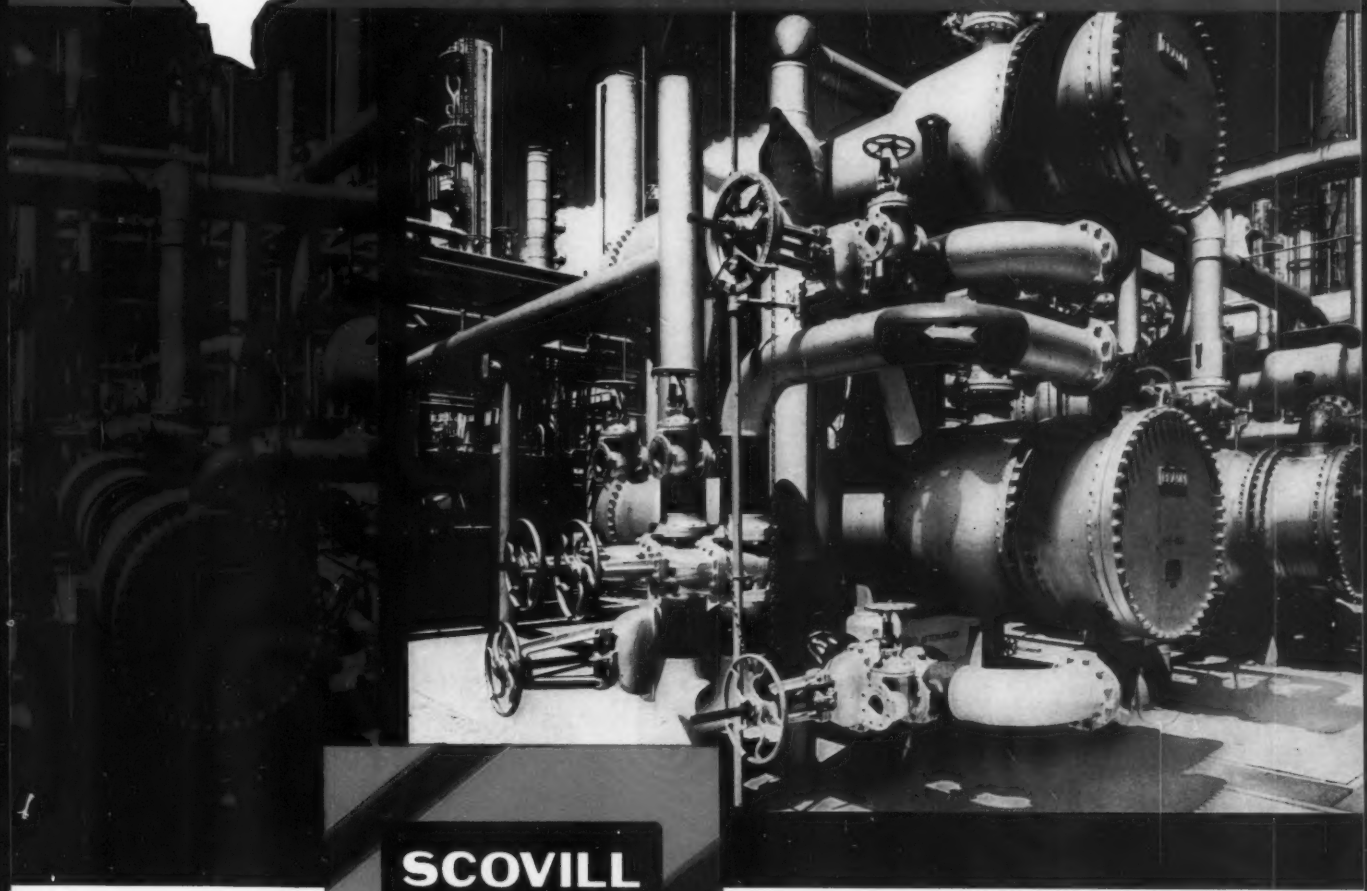
For more information on how SDC Duclones can keep "Big Cats" cracking, send for bulletin C-2058.

THE Ducon COMPANY INC.
147 EAST SECOND STREET • MINEOLA, L. I., NEW YORK
CYCLONES • CENTRIFUGAL WASH COLLECTORS • TUBULAR CLOTH FILTERS • DUST VALVES
Canadian Branch:
THE DUCON COMPANY, of CANADA, Ltd., 1121 Penin St., BURLINGTON, ONTARIO, CANADA

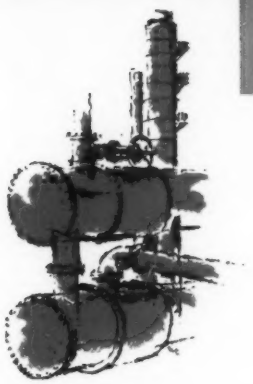
Petro-Tex®

where trouble-free performance is a matter of pride...

CHEMICAL CORPORATION • HOUSTON, TEXAS



SCOVILL®



HEAT EXCHANGER TUBE for Applications from Marine to Petrochemical, from Compressor Intercoolers to "Cat-Cracker" Exchangers, in these popular Alloys . . . Phosphorized Admiralty • Admiralty • Arsenical Admiralty • Red Brass, 85% • Deoxidized Copper • Arsenical Copper • Cupro-Nickel, 10%-20%-30% • Aluminum Brass • Aluminum Bronze, 5% • Muntz Metal • Duplex Tube

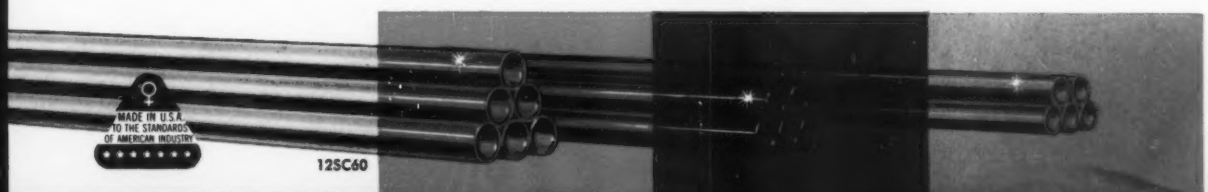
HEAT EXCHANGER TUBE

As in so many other modern chemical and petro-chemical processing plants, these typical heat exchanger units at the Houston Plant of Petro-Tex Chemical Corporation are tubed with Scovill PHOSPHORIZED (Inhibited) ADMIRALTY Heat Exchanger Tube. This alloy has often been specified by operating engineers for assured trouble-free performance under conditions where dezincification has been a problem and because of its excellent resistance to the effects of sulphur compounds, acid or contaminated fresh or salt waters. The range of permissible conditions for using this alloy is quite wide.

Similarly, Scovill's eleven other popular heat exchanger tube alloys have been formulated to meet specific service needs. Scovill Technical Service with an exceptional background of experience in this special field can help you select the alloy best suited to assure trouble-free performance in your installation.

SCOVILL MANUFACTURING COMPANY

Mill Products Division, 99 Mill Street, Waterbury, Connecticut. Phone PLaza 4-1171



12SC60

Why do sweater girls look to the oilman? Simple. He's responsible for the petroleum-based synthetic fibers that go into so many of the sweaters they wear. And for the petroleum-based synthetic dyes that are used to color them. Because of oil research, clothing for the whole family has better appearance and longer life. Each advance in oil technology gives you, the oilman, a greater stake in society. And gives you more reason to speak up when anyone speaks out against oil. Today, everyone enjoys the benefits of oil—one of nature's most versatile resources.

SHELL OIL COMPANY

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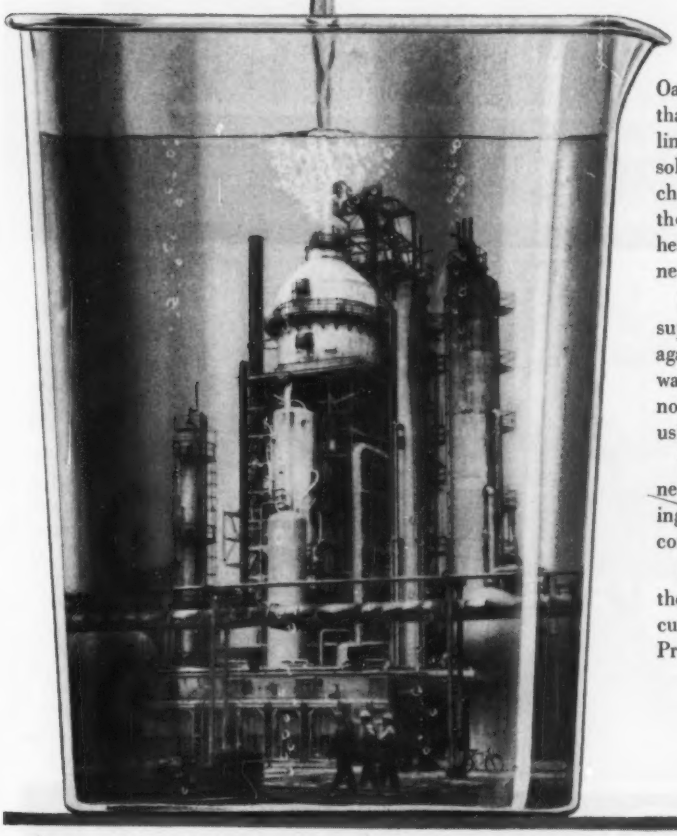
ANNOUNCING:

OAKITE ACALAID®

New additive "supercharges" acid and alkaline cleaning solutions... boosts detergency to remove toughest soils



Oakite Acalaid is a newly-developed liquid additive that steps-up the cleaning efficiency of acid or alkaline solutions against problem soils. It contributes solvent action to their detergency. It has a supercharging effect that gives extra power to pry loose those tenacious carbon and scale deposits found in heat exchangers and processing columns. Now you'll need less time to do a more thorough cleaning job.

In just a few months of field testing, Acalaid's supercharging ability has been proved time and time again. To cite one case: At a refinery, the tower that was traditionally toughest of all to clean was pronounced "slick as a hound's tooth" after a turnaround using Oakite 85 and Acalaid.

Two "plus" benefits: (1) Acalaid often eliminates need to increase concentration of the regular cleaning solutions; (2) it leaves a light film that inhibits corrosion.

Ask the Oakite man about it. He'll help you figure the best concentration to boost cleaning power of your current materials. Or write for free Bulletin. Oakite Products, Inc., 48 Rector Street, New York 6, N. Y.

OAKITE

SCIENCE

over 50 Est. 1909 years' leadership in industrial cleaning

For more data on advertised products, use Readers' Service Cards, last page.

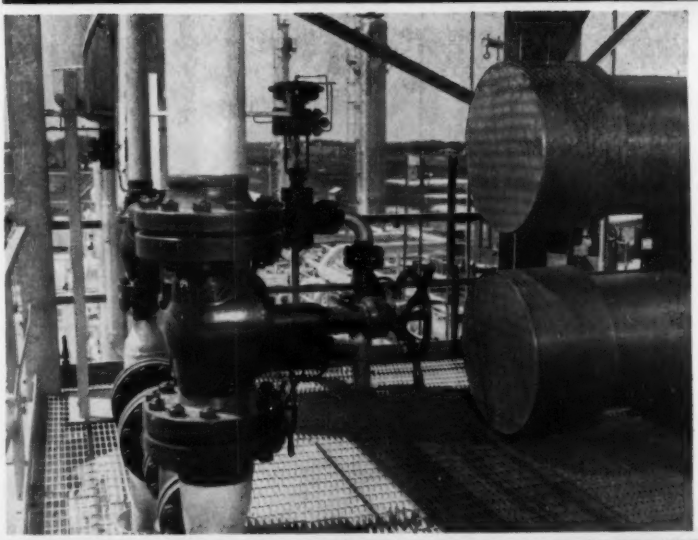
This Ammonia Refrigerant System Uses ORBIT

FOR BETTER OPERATION
SAFER, EASIER MAINTENANCE

ASA CLASS VALVES

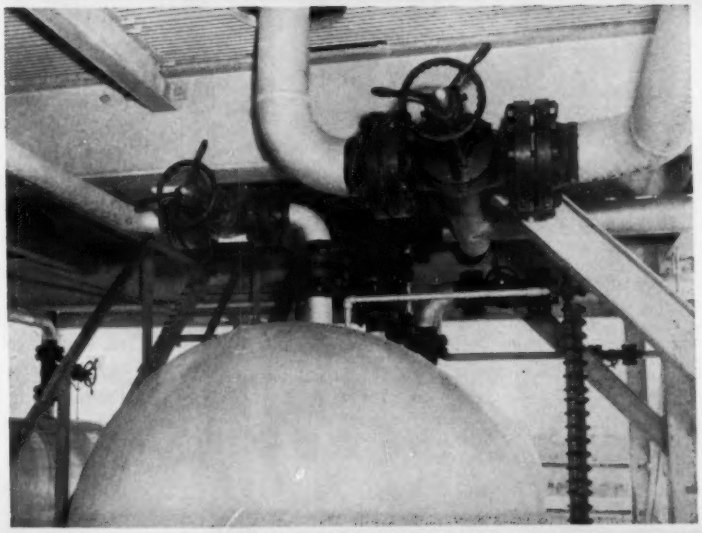
In addition to the services shown in these pictures of a Louisiana Gasoline Plant — ORBIT ASA CLASS VALVES are used in other areas of the ammonia refrigerant system, i.e.,

- Relief valves for ammonia condenser
- By-Pass control valves for strong aqua pumps
- Products storage and transfer valves
- Suction and discharge manifolds
- Relief valves for ammonia absorber
- Discharge valves — weak and strong aqua transfer pump



WEAK AQUA RATE CONTROL VALVE, NEAR SIDE AND AMMONIA STILL REFLUX CONTROL VALVE, FAR SIDE.

AMMONIA SURGE TANK AND RELATED PIPE.



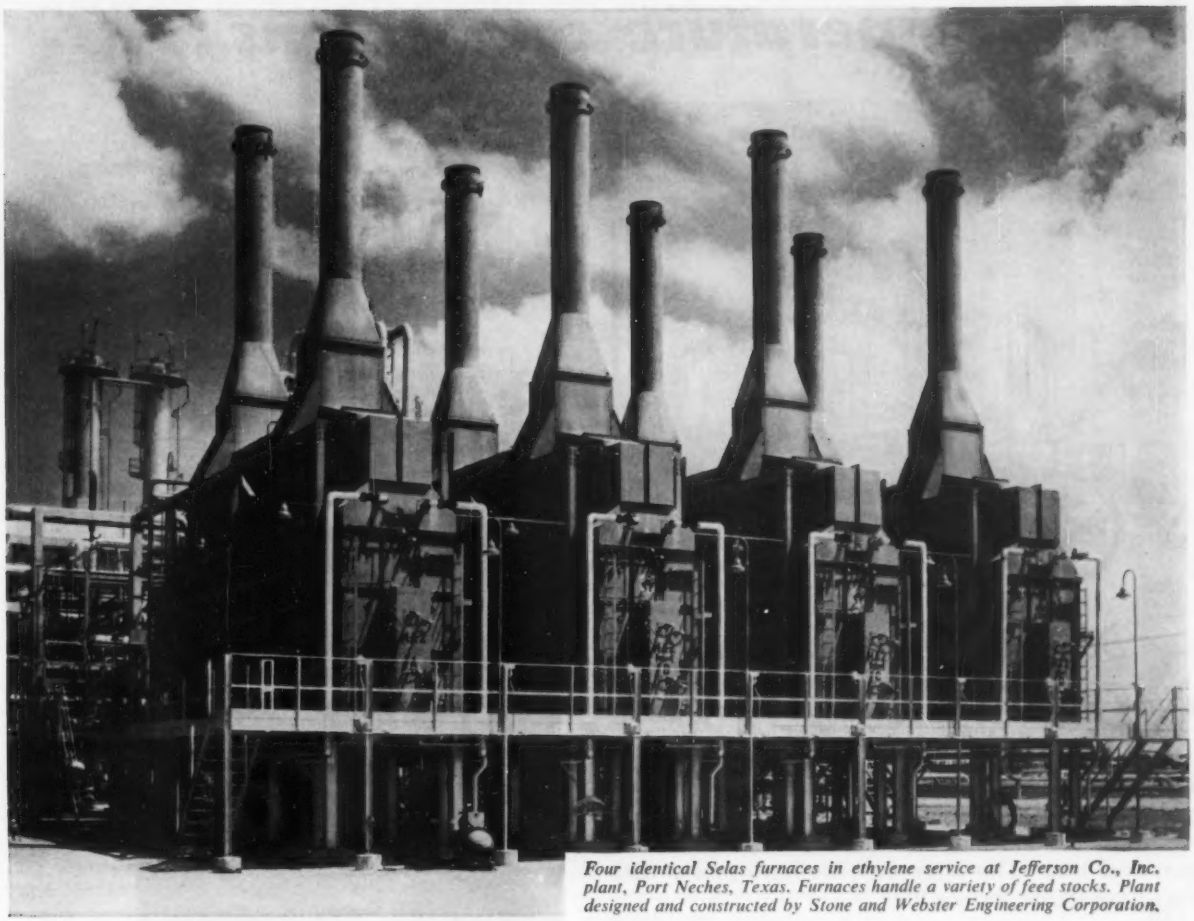
WHERE VALVE SPECIFICATIONS DEMAND NO LEAKS/NO LUBRICANTS, ORBIT ASA CLASS VALVES FILL THE BILL!

ORBIT VALVE COMPANY

ORBIT VALVES

P. O. BOX 699 / TULSA, OKLAHOMA
PHONE LUther 4-4761 TWX TU 925

NEW SLANTS ON HEAT PROCESSING FROM SELAS



Four identical Selas furnaces in ethylene service at Jefferson Co., Inc. plant, Port Neches, Texas. Furnaces handle a variety of feed stocks. Plant designed and constructed by Stone and Webster Engineering Corporation.

Jefferson Chemical obtains heat uniformity preciseness · zone control · with Selas GRADIATION®

In ethylene production at Jefferson Chemical Co., the following inherent features of GRADIATION heating have been translated into . . . longer on-stream periods . . . fixed amount of production with less feed stock . . . greater depth of cracking when limited by actual metal temperatures:

- Zone Control . . . DURADIANT® burners are adjusted to desired heat pattern, in horizontal rows, to produce optimum reactions in pyrolysis.
- Uniformity of heating . . . even-heat distribution along and around tubes, increases tube life by eliminating hot spots, minimizing coke formation.
- Preciseness of heating . . . complete combustion within DURADIANT burner cup permits placing burners close to tubes . . . achieving fast heat-up and instantaneous response to controller demand.
- Versatility . . . GRADIATION heaters handle a variety of feed stocks, interchangeably, under optimum conditions.

May we arrange for a Selas field engineer to discuss your heat processing needs with you? For this service—without obligation—or for a copy of Bulletin "Gradiation Heating for Petroleum and Chemical Processing," write to Fluid Processing Division.

SELAS CORPORATION OF AMERICA
73 Dreshertown Road, Dresher, Pa.

EUROPEAN SUBSIDIARY: Selas Corporation of America, European Div., S.A., Pregny, Geneva, Switzerland. INTERNATIONAL AFFILIATES: Benelux, Canada, England, France, Germany, Italy, Japan, Portugal, Spain.

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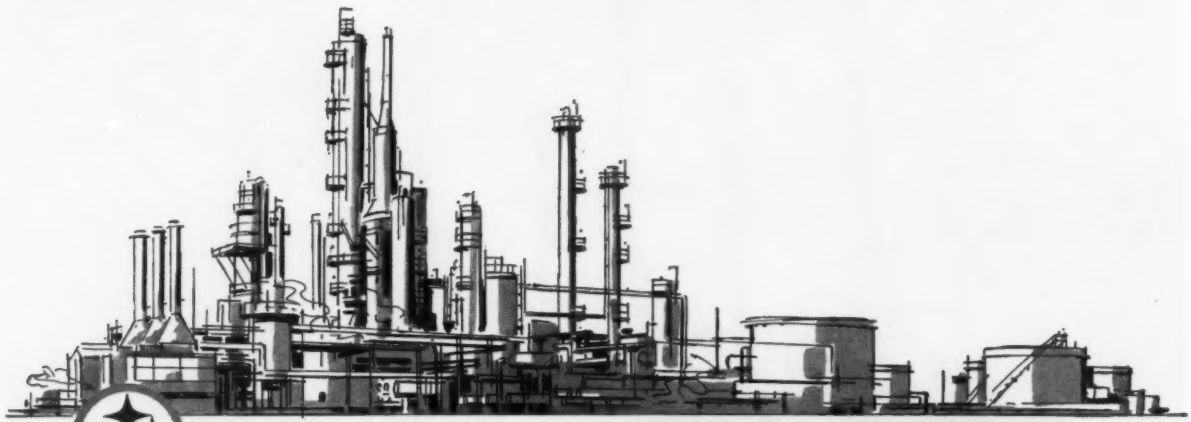
SELAS

HEAT AND FLUID PROCESSING ENGINEERS
DEVELOPMENT / DESIGN / CONSTRUCTION

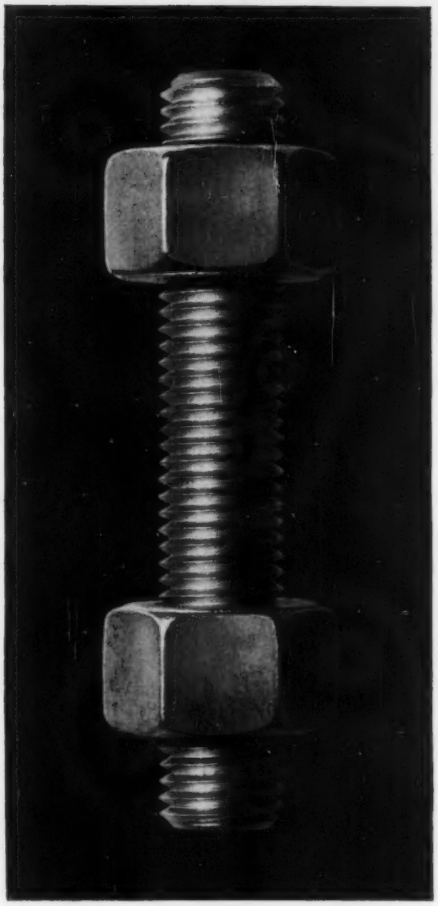
For more data on advertised products, use Readers' Service Cards, last page.

Low-cost bolting for high-temperature connections . . .



Steel *for Strength . . . Economy . . . Versatility*

Bethalume-coated alloy studs and quenched nuts



For high temperatures and in severely corrosive refinery service—you can rely on Bethlehem's Bethalume-coated continuous-thread alloy studs and quenched nuts. This is because we have *proved* that they have longer service life.

A series of tests, held at temperatures higher than normal refinery conditions, showed virtually no weight change in the Bethalume-coated samples. Another series of tests, conducted in highly corrosive refinery atmospheres, revealed no appreciable corrosion of the Bethalume-coated samples over a four-year period.

Look at the other advantages of Bethalume coating:

1. Double-layer protection: pure aluminum coating on top of a metallurgically bonded, iron-aluminum alloy.
2. Uniform coating.
3. High-temperature galling is minimized.

Full details on how Bethalume coating assures *low-cost* bolting at *high-temperatures* can be obtained from the nearest Bethlehem office. Or simply write a letter or postcard to us at Bethlehem, Pa.

BETHLEHEM STEEL COMPANY, BETHLEHEM, PA., *Export Sales:* Bethlehem Steel Export Corporation

BETHLEHEM STEEL

BETHLEHEM STEEL

A Nalco PRODUCT MANAGER

Answers Questions About Refinery Equipment Fouling And Successful Anti-Fouling Programs

Both Organic and Inorganic Deposits in Refinery Equipment Raise Operating Costs, Decrease Throughput

Corrosion control, desalting, oxygen scavenging, gas blanketing and adjustment of process variables will help to reduce exchanger fouling—but in many systems, fouling continues to cause trouble. Here are some of the questions that are asked, and the answers we had to find to them in order to develop anti-fouling programs of real value to refineries.

Question: What causes fouling in refinery systems?

Answer: Inorganic salts, corrosion products and organic polymers. Inorganic salts are carried into exchanger trains by water dispersed in the hydrocarbon, and deposit out as the water is vaporized on heating. Corrosion products may be carried into exchangers from other units, or corrosion may occur in the exchangers themselves. Organic polymers are insoluble, polar, high-molecular-weight materials, formed as the hydrocarbon is heated.

Question: Where does fouling occur?

Answer: Fouling may occur in virtually any part of a refinery system; however, these are the areas where fouling is usually most troublesome: heat exchangers and furnaces ahead of catalytic and thermal cracking units, reforming units, and crude units, fractionating towers, reboilers and overhead condensers. Types and amounts of deposits vary, depending on the charge stock, corrosion control measures, and process variables.

Question: Why is an anti-fouling program necessary?

Answer: Because of the high cost of processing in fouled equipment, created by: reduced heat transfer; lowered throughput; downtime; and direct cleaning costs.

Question: How does Nalco solve fouling problems?

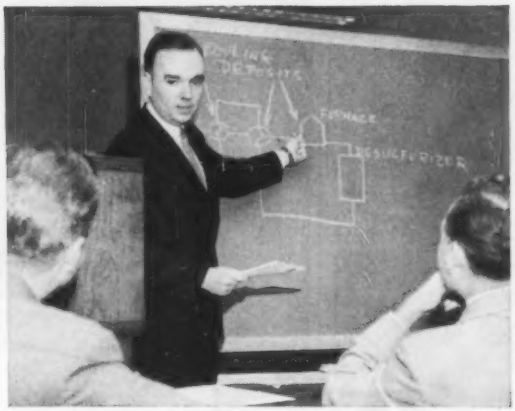
Answer: By making a careful analysis of the system, locating units where fouling occurs, and finding the sources of fouling. When these facts are available, recommendations are made for an anti-fouling program.

When the program is in operation, Nalco field representatives maintain close contact with operating personnel, cooperating to secure continuously successful, economical results.

Question: What is Nalco's anti-fouling program?

Answer: It is a program designed for a specific refinery system to eliminate corrosion, organic polymer formation, and any other sources of fouling. Where fouling is due to potential deposit-forming materials in charge stocks, Nalco-developed chemicals are recommended to stabilize and disperse these materials.

Usually anti-fouling additives are used in combination with Nalco corrosion control chemicals; and, where indicated, following Nalco desalting chemicals.



R. C. Canapary, Product Manager, Petroleum Industry Chemicals Department, Nalco, is a Doctor of Chemical Engineering, whose experience includes technical and engineering work at Nalco, as well as several years with a major oil company.

The assistance of Nalco representatives in regularly recording and evaluating the effects of temperatures, heat transfer rates, pressures, and other process variables helps to assure optimum results in operating efficiency and treatment economy.

Research and development work is a continuing part of the Nalco anti-fouling program. Nalco researchers use specially-designed equipment to simulate plant operations. Conditions can be established to accelerate fouling rates and speed development of promising new chemicals.

Question: How long does it take to establish the Nalco anti-fouling program?

Answer: A Nalco anti-fouling program can begin promptly at your request. Nalco considers a program established when anti-fouling and corrosion control results are proven satisfactory.

The electrical resistance method of corrosion evaluation, corrosion coupons, iron-in-water tests, operating records (temperature, pressure, heat transfer coefficients) and direct inspections should be used to evaluate the program's effectiveness.

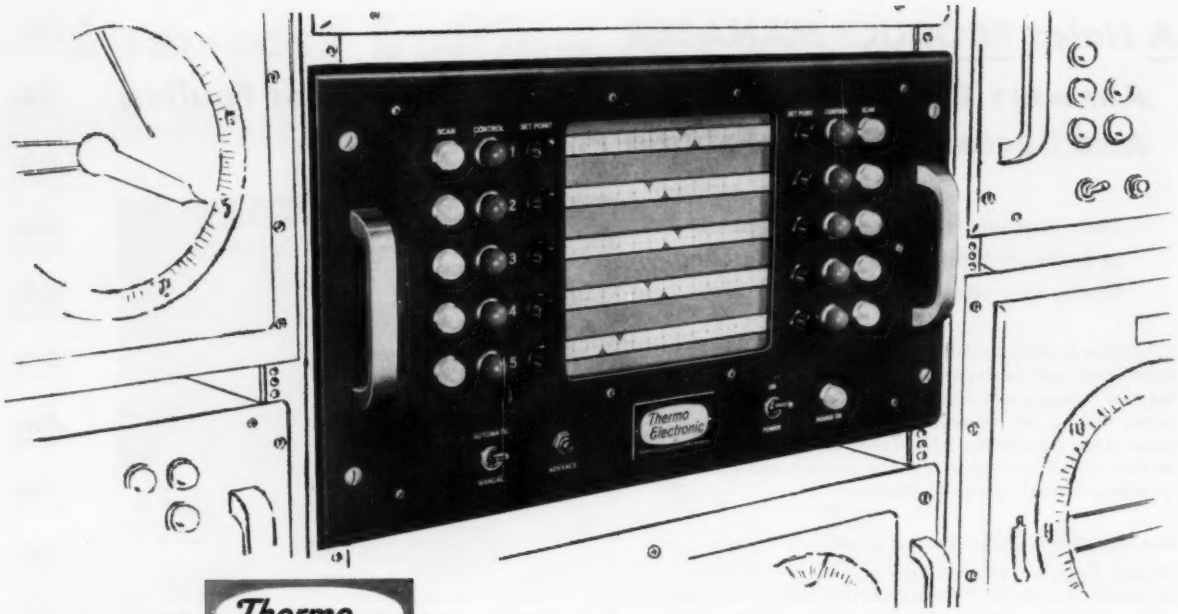
Suggestion: Get full details on a Nalco anti-fouling program for your operation. For quick action, call your Nalco Representative, or write to me at Nalco: Dr. R. C. Canapary, Product Manager, Petroleum Industry Chemicals Department.

NALCO CHEMICAL COMPANY
6259 West 66th Place • Chicago 38, Illinois
Subsidiaries in England, Italy, Mexico, Spain, Venezuela and West Germany
In Canada—Alchem Limited, Burlington, Ontario

Nalco® ... Serving Industry through Practical Applied Science

Nalco CHEMICALS
Nalco SERVICES

For more data on advertised products, use Readers' Service Cards, last page.



ONE Thermo Electronic Multi-Point Controller

Controls TEN Process Temperatures

One, compact "Thermo Electronic" Multi-Point Controller gives you, sensitive, accurate, automatic . . .

- Two position (off-on) control of up to ten separate process temperatures; also controls flow, pressure, pH, Strain gages, and other operations.
- Three position control of five separate processes!
- Single point constant control of any critical process!
- Manual-Balance Indication of exact process conditions!
- Monitoring of extra points or those already under control!

Ten in One

One instrument does the job of ten individual controllers. You save—40 to 60% of initial cost—up to 75% of panel space —cut installation time and cost—minimize maintenance!

Clean, Simple, Functional Design

The "Thermo Electronic" Multi-Point Controller has front-set controls for easy operation. Routine maintenance is also done from the front, without removing unit from panel or relay rack. Available in either potentiometer or bridge measuring circuits, with an extremely stable constant voltage supply, the instrument provides long-lived, trouble-free control of practically every process suitable to off-on control action. Sensitivity is 15 microvolts independent of scale span—Accuracy is ±0.5% of scale span.

Operation

Sensing element input signals are compared, in sequence, to individually adjustable slide-wire set-points. Signal deviations are amplified by the "Thermo Electronic" high-gain relay control amplifier, and used to actuate load relays connected to the points being controlled.

Scanning sequence is governed by a stepping switch and electronic timer. Scanning rate—3 seconds per point. Other scanning speeds are available by simply changing one carbon resistor.

Ten white lights on the instrument panel show scanning position—ten red lights show process condition. Ten knobs permit adjustment of individual set-points on the range scales. Ranges are available for thermocouples, resistance temperature detectors and other types of suitable transducers.

Maintenance is Easy

The instrument slides forward on built-in tracks. Simple adjustment and inspection is easily accomplished from the front. The plug-in or screw-terminal components are easily replaced—fully protected from dirt and corrosive atmosphere. The whole instrument is gasketed to further protect components.

Safety Engineering

Critical circuitry is fused against overloading. A failsafe circuit is provided to protect processes against thermocouple burn-out and amplifier component failure.

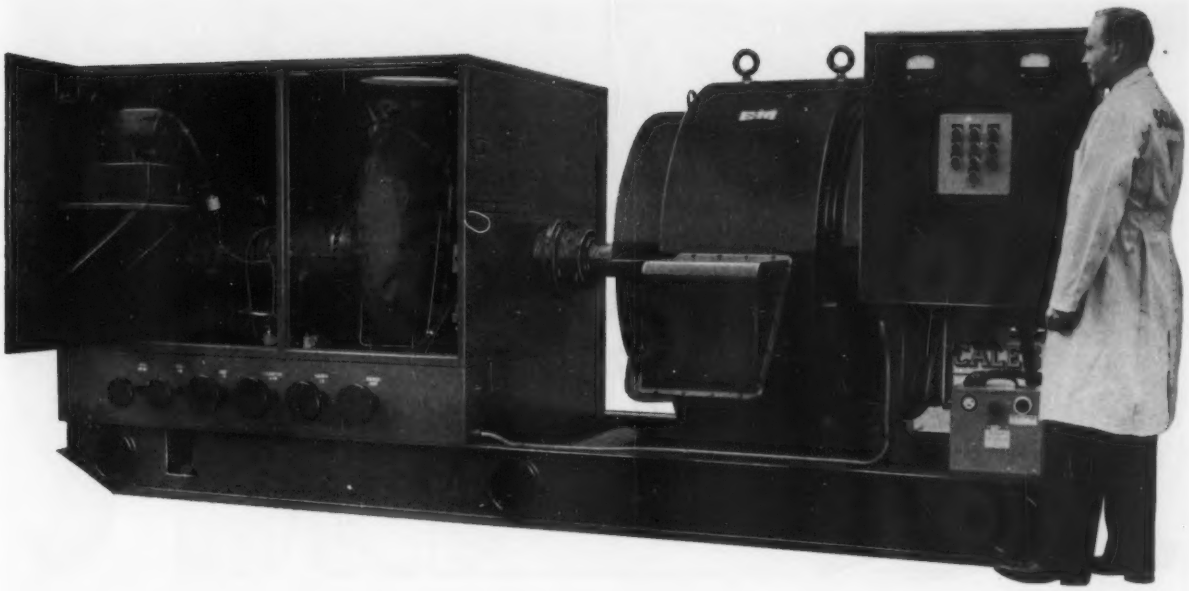
Write today for Instrument Section 52-19

Thermo Electric

Temperature Measuring Systems and Components

20 YEARS

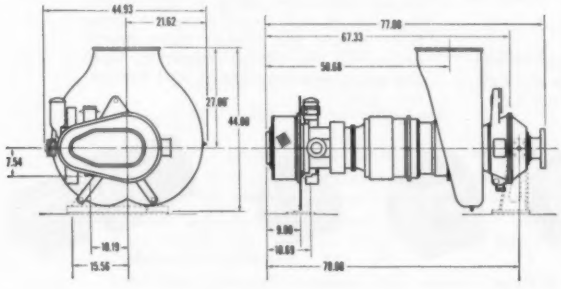
THERMO ELECTRIC Co., Inc., Saddle Brook, New Jersey
In Canada: THERMO ELECTRIC (Canada) LTD., Brampton, Ont.



800 KW!

Solar industrial gas turbine generator sets ideal for peak loading or constant duty

Versatile, compact industrial generator sets powered by Solar's T-1000 gas turbine engine have a nominal rating of 800 kw. They are ideal for either peak loading or constant duty electrical power applications. Simple design and rugged construction reduces maintenance



to a minimum. Installation is extremely simple. The engine is about 1/10th as heavy as diesel units of similar horsepower and occupies only 51 cu ft. No elaborate foundation or flooring base is required because the gas turbine is practically vibration-free.

Equipped with one of the several control systems available, the engine can be operated remotely and entirely automatically. It starts instantly and operates at full load without warmup, even after long periods of standby service.

Fuel economy of the Solar T-1000 engine is unmatched in its field. The engine runs equally well on a variety of fuels including gasoline, diesel fuel and natural gas. The exhaust may be used in a waste heat boiler or as combustion air in process apparatus or conventional boilers.

Cost of this gas turbine is competitive with diesel engines in many industrial applications. For further information on Solar's turbine-powered generator sets, its complete line of gas turbine engines or industrial compressors, write to Dept. H-214, Solar Aircraft Company, San Diego 12, California.

SOLAR

A subsidiary of International Harvester Company

For more data on advertised products, use Readers' Service Cards, last page.

REMEMBER COLLAR BUTTONS?

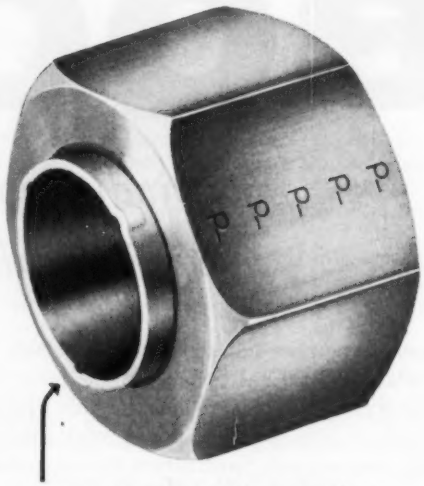
NOW **PARKER** HAS ELIMINATED A MORE SERIOUS ANNOYANCE ...LOST TUBE FITTING FERRULES!

A simple change in the design of Parker "Intru-lok®," the positive, bite-type Parker fitting for copper, aluminum or plastic tubing, has solved an age-old problem.

Small three- and four-piece tube fittings have long been a pain in the neck on applications where it is necessary to remove the nut from the fitting. The ferrule(s) fall out and promptly disappear. If and when found, they often get put in backwards. Sometimes they never get put back at all. Result, in either case: a leaking joint.

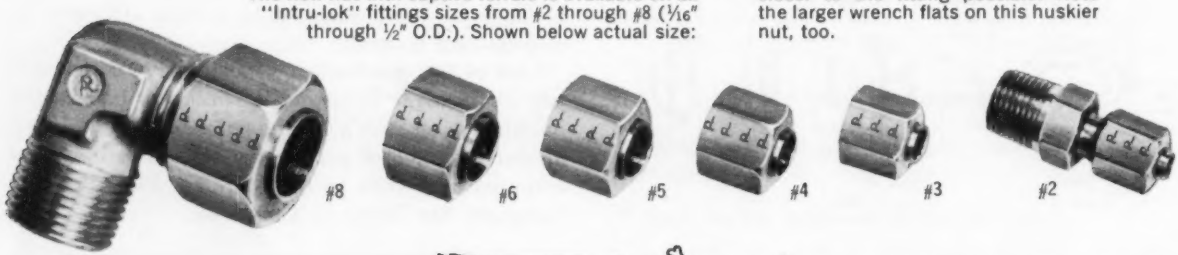
Now Parker has developed a snap-in, captive ferrule for "Intru-lok." You can take it out of the nut, "on purpose," but you can't drop it out accidentally.

You get all the leakproof safety of a three-piece fitting with positive "bite." You also get the convenience, the quick, easy assembly of a two-piece fitting. The easiest fitting to install has been made even easier. Write for new "Intru-lok" dimensions and prices today.



Three "detents" hold the "tail" of the new ferrule in the nut. Also, the larger hole in the nut makes tube bends closer to the fitting possible. Note the larger wrench flats on this huskier nut, too.

The new nut with captive ferrule is available on all "Intru-lok" fittings sizes from #2 through #8 (1/16" through 1/2" O.D.). Shown below actual size:



PARKER HANNIFIN CORPORATION

3278-PH

Parker FITTINGS AND HOSE DIVISION

17325 Euclid Avenue • Cleveland 12, Ohio

PNEUMATIC AND HYDRAULIC SYSTEM COMPONENTS

EUROPEAN DIVISION • PARKER-HANNIFIN N.V. • SCHIPHOL • THE NETHERLANDS

For more data on advertised products, use Readers' Service Cards, last page.

AT COSDEN . . .

After five years' experience in operating Combin-aires, Cosden Petroleum Corporation, at its Big Spring refinery, has installed its FOURTH Hudson Combin-aire.

The Combin-aire is an integrated structure combining a water cooling tower with fin-tube hot fluid to air exchangers. Ambient air is cooled as it is drawn thru the water, and the cooled air serves as the cooling medium for the fin-tube coolers. Thus, with fin-tube coolers, effluent process stream temperatures may be reduced far below those obtained with ambient air.

The Combin-aire may be used primarily as a cooling tower, with the advantages of double use of air, and, because hot effluent air is undersaturated, complete elimination of spray carry over or condensation. Or when water is scarce, or salt, or brackish the Combin-aire may be used primarily for fin-tube cooling, using minimum water of any quality for pre-cooling air.

DEPENDING UPON DESIGN OBJECTIVES THE COMBIN-AIRE MAY HAVE SOME OR ALL OF THE FOLLOWING ADVANTAGES:

- **Absolute minimum water consumption consistent with attainment of low terminal process stream temperatures.**
- **Water circulation may be made automatically responsive to air temperatures with no water circulated except at high ambient temperature.**
- **No water treatment necessary. Salt water or brackish water may be used.**
- **No spray carryover or condensation. After passing across the fin-tube elements the heated air leaving the Combin-aire at elevated temperature is undersaturated with water vapor and cannot precipitate condensate or carry water spray.**
- **Minimum piping. Combin-aire may be installed immediately adjacent to other process equipment.**
- **Clean air to fin-tube units. During the hot season air is washed, removing dust, sand and insects.**

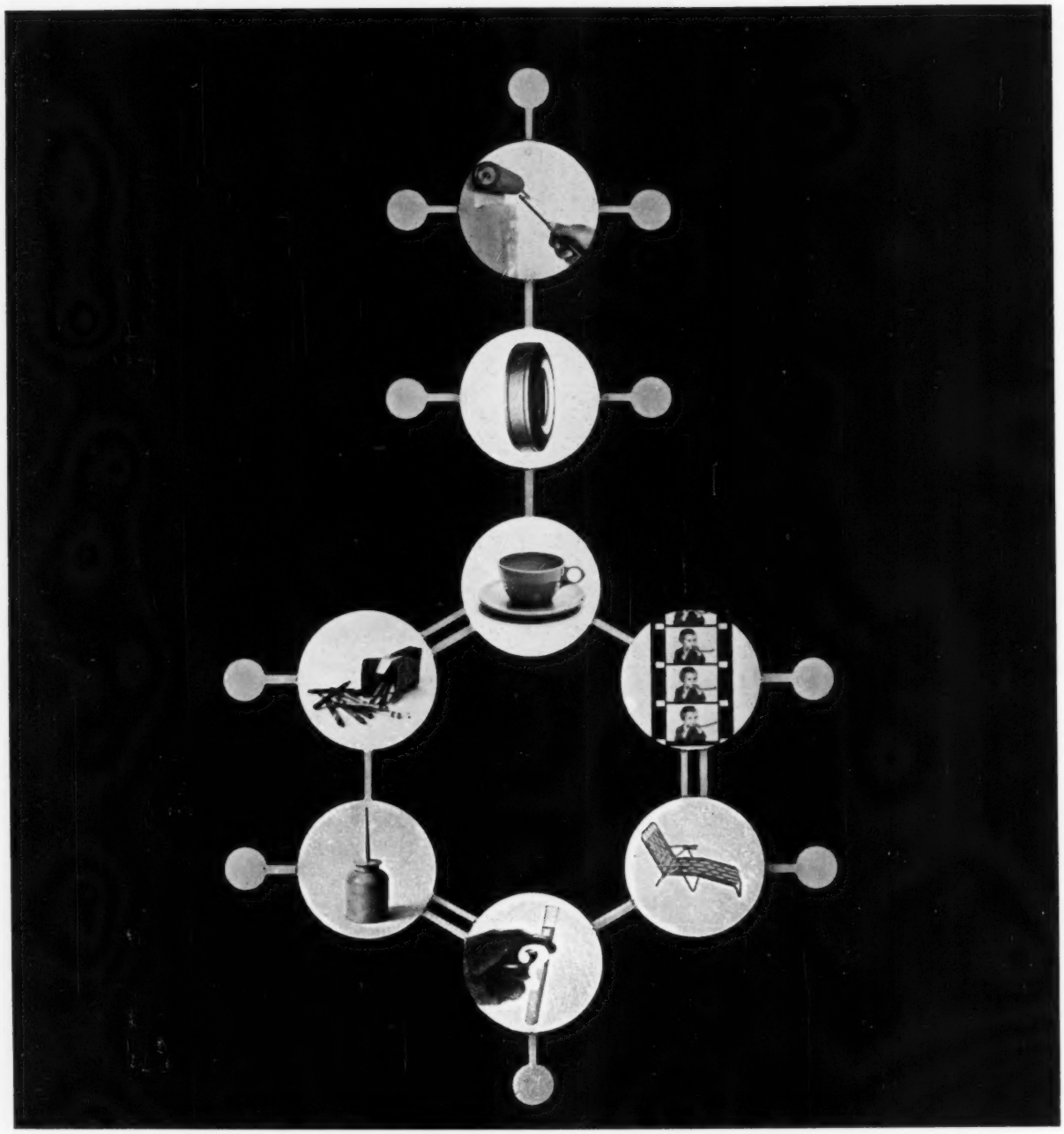
Effluent temperatures of process streams may be accurately controlled with HUDSON Auto-variable pitch fans.

HUDSON

ENGINEERING CORPORATION

BRAEBURN STATION • HOUSTON, TEXAS

OFFICES: 16033 Ventura Blvd. Encino, California • 122 East 42nd St. New York 17, N. Y. • 199 Bay Street Toronto, Ontario, Canada • 17 Stratton St. Piccadilly London W. 1, England • Corrientes 1115 Buenos Aires, Argen • Rua Mexico 45 Rio de Janeiro, Brazil



"More than three thousand different hydrocarbon compounds have been produced from oil and natural gas. So far, some three hundred of them are commercially important. But scientists believe there are many more useful hydrocarbon derivatives still to be discovered. Out of this test-tube cornucopia will come a multitude of new products to meet the expanding needs of tomorrow."

— M. J. Rathbone, President

Standard Oil Company (New Jersey)

(WHOSE PRINCIPAL U. S. OPERATING AFFILIATE IS HUMBLE OIL & REFINING COMPANY)

For more data on advertised products, use Readers' Service Cards, last page.

What the affiliation of Rochester Manufacturing Co. with American-Standard® means to you

Perhaps you read the story in the WALL STREET JOURNAL. "American Radiator and Standard Sanitary Corp. . . . has acquired Rochester Manufacturing Co., maker of gauges and instruments. Rochester Manufacturing will operate as a part of American-Standard Controls Division."

There was more. But what is of immediate concern to you is: what does this consolidation of two great names in the field of instrumentation mean to the petroleum and chemical industries?

It means expansion of Rochester Instruments' research and development program, reflecting broader product lines.

It means that the scope of the Rochester operation will be increased to serve industry more effectively.

It means that the complete facilities and capabilities of the American-Standard Controls Division are at your disposal as Rochester engineers work with you.

In short, it means *growth* . . . greater resources and development of important new products to take their place beside Rochester thermometers and pressure gauges—and Detroit Pressure and Temperature controls, Norwood Electrosyn systems and Strain Gauge Pressure Pickup.

We look forward to the opportunity, as we always have, to help you keep pace with America's growth and development, but now we meet the challenge with a greater abundance of resources.

The familiar RMC trademark, symbol of quality instrumentation, has undergone a design change as a result of the affiliation of Rochester Manufacturing Co. with American-Standard. Here *(right)* is the new trademark for Rochester Instruments, and this is our new name: American-Standard Controls Division, ROCHESTER INSTRUMENT PLANT, 38 Rockwood Street, Rochester 10, New York.

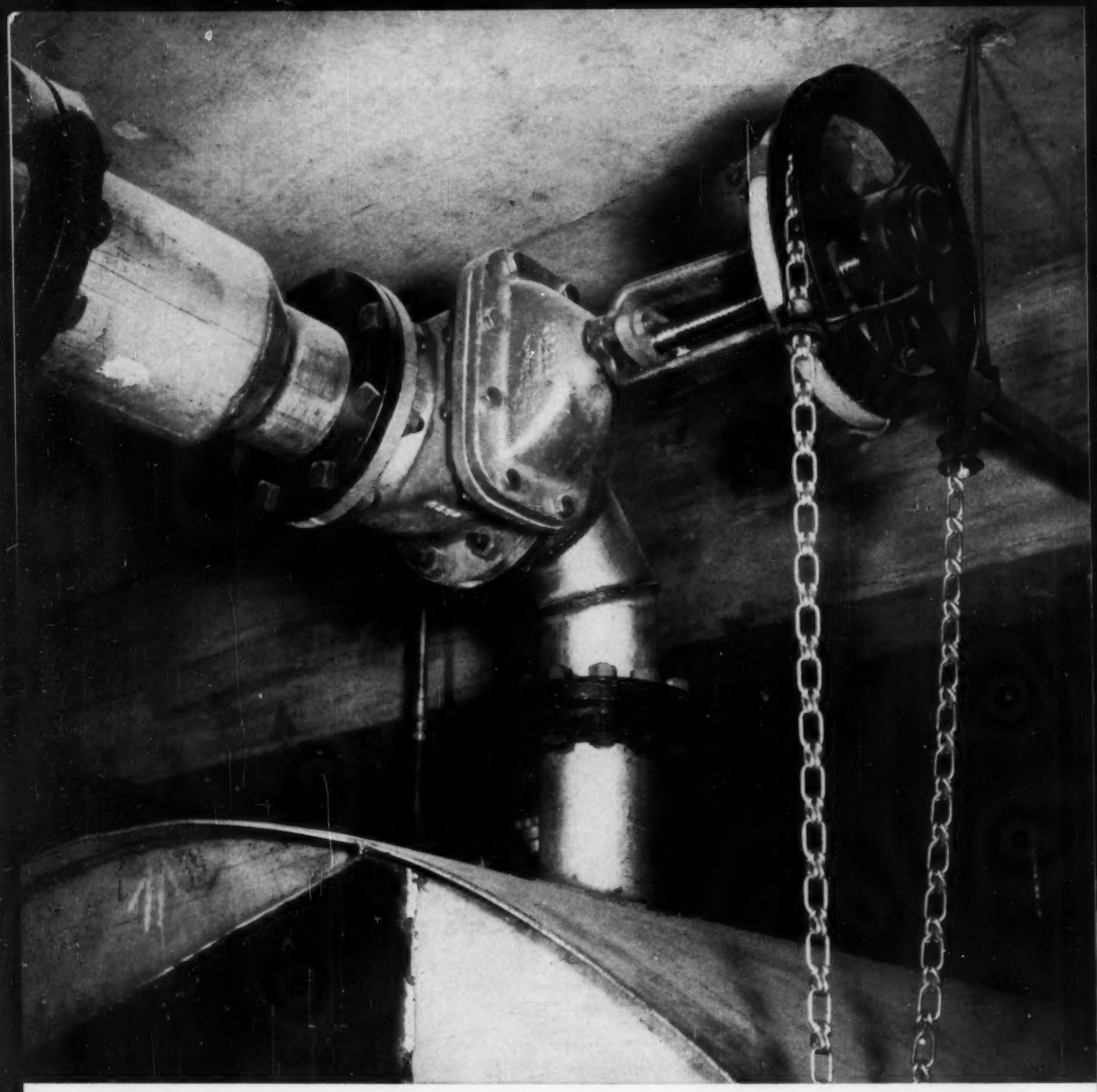
AMERICAN-Standard
CONTROLS DIVISION

Rochester Thermometers

Rochester Pressure Gauges

NORWOOD Strain Gauge Pressure Pickup (to 100,000 psi.)

DETROIT Pressure Control Switch



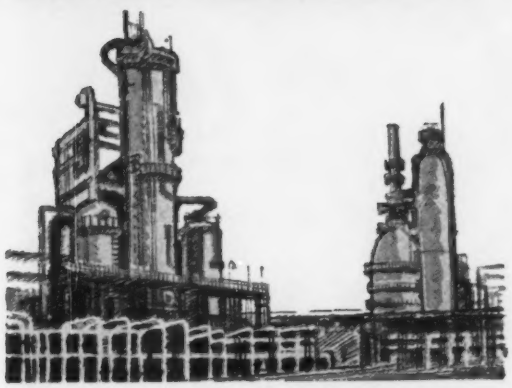
FILM GUARDIAN AT WORK... Eastman Kodak takes no chances on contamination at 1,000 acre Kodak Park in Rochester, N. Y. The 7-year-old Aloyco Stainless Steel Valve (above) helps eliminate danger from rust or contamination that could easily spoil the film base, which is later coated with a sensitive photographic emulsion. Today, thousands of industrial processes are being safeguarded by Aloyco corrosion resistant valves.

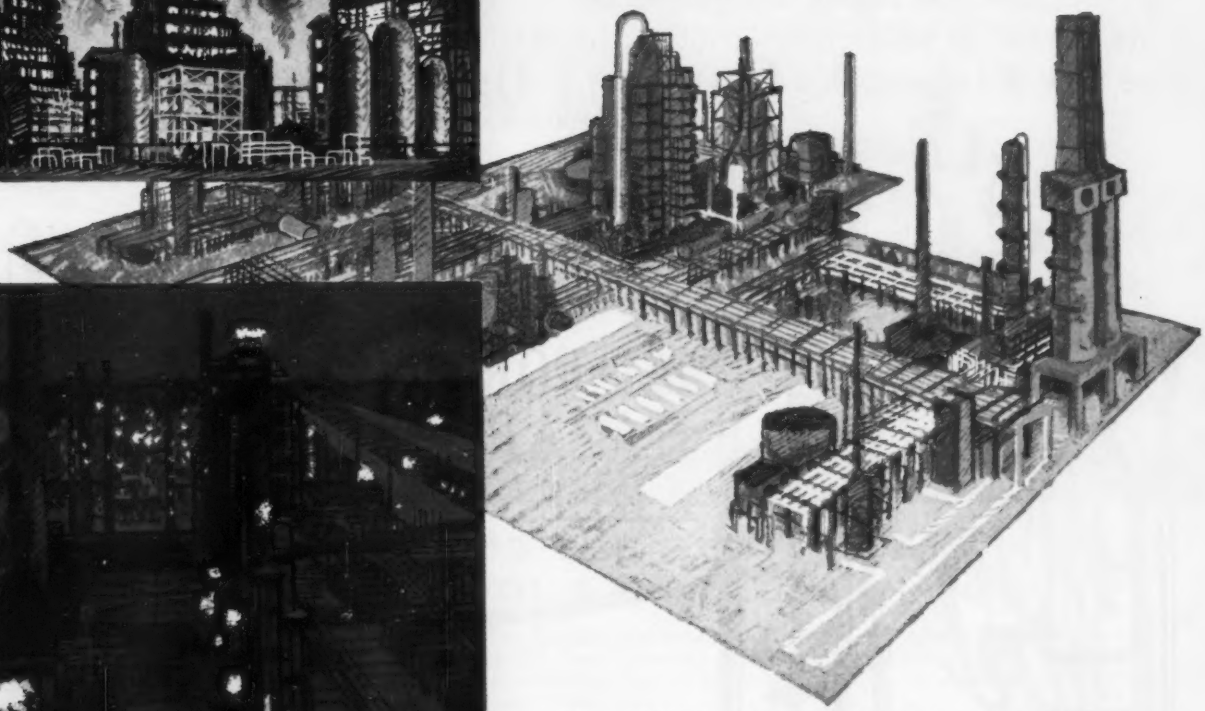
Want specific examples in your field? Our engineers will be glad to help. Just write Alloy Steel Products Company, Inc., 1303 West Elizabeth Avenue, Linden, N. J. O-1

ALLOY STEEL PRODUCTS COMPANY

Boston • New York • Wilmington • Atlanta • Birmingham • Baton Rouge • Buffalo • Pittsburgh • Chicago • St. Louis • San Francisco • Los Angeles • Seattle

Who we serve proves *how* we serve





Since 1923, the world's leading petroleum refineries, chemical plants and other process installations have operated with the aid of Pacific centrifugal pumps. Their satisfaction with the cost-cutting efficiency provided by Pacific pumps is apparent in continuing repeat orders for plant expansion and new facilities.

There are several advantageous reasons for these re-orders; among them: (1) Pacific is a specialist in the development, design and manufacture of centrifugal pumps. (2) Pacific manufactures a wide variety of types and sizes to fill specific needs at the most beneficial cost/efficiency level. (3) Pacific provides technical advice and counsel to customers through an experienced sales engineering staff. (4) Pacific pumps may be financed in the leading currencies of the world.

There are other reasons why Pacific can serve you best. We would welcome an opportunity to tell you about them.

PACIFIC

PACIFIC PUMPS

Offices in all Principal Cities *Inc. . . A Division of Dresser Industries, Inc.*

HUNTINGTON PARK, CALIFORNIA

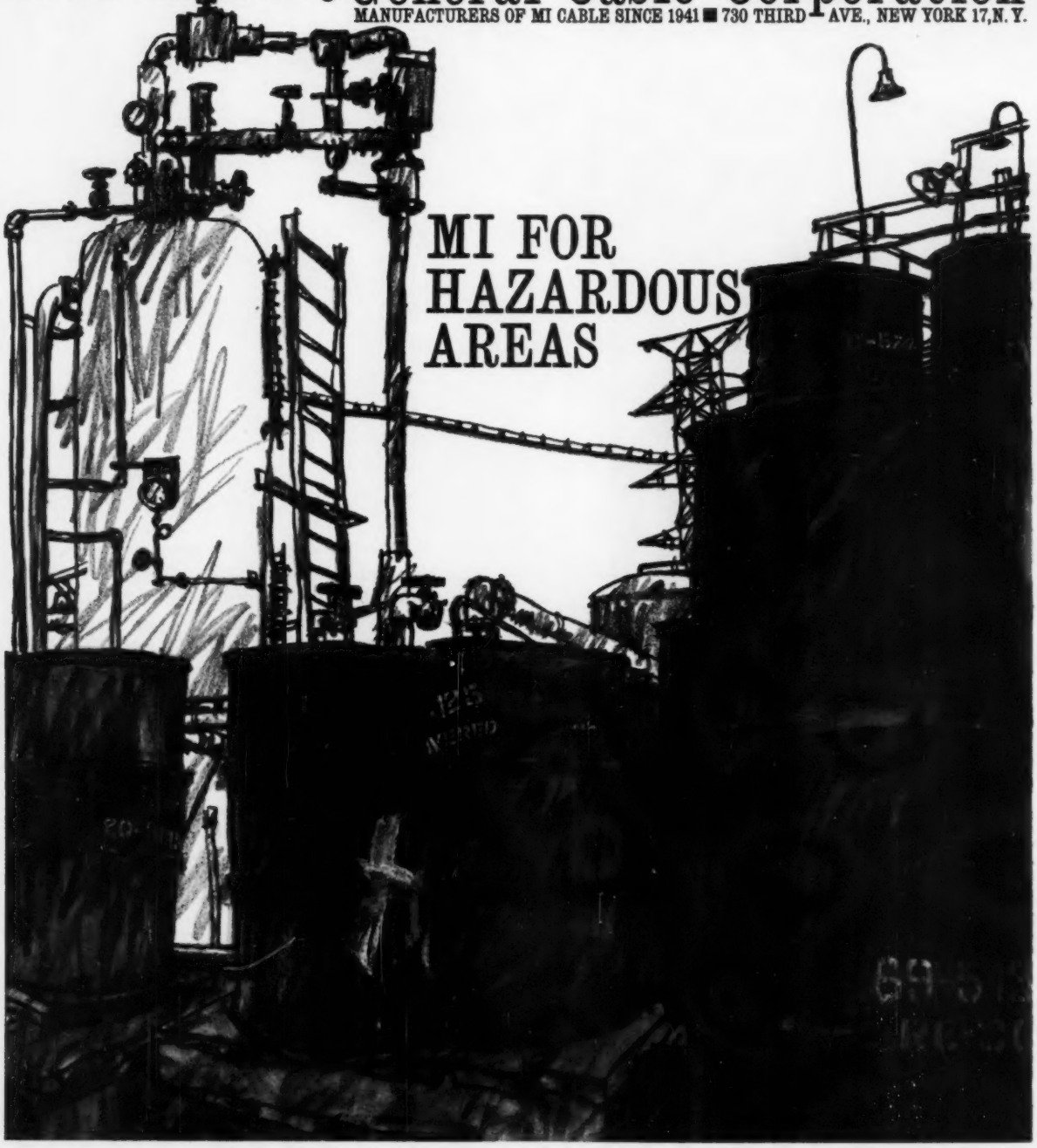
IN-3

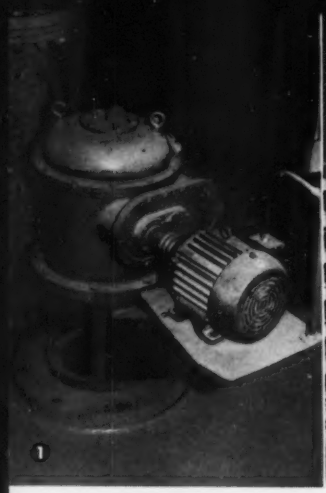
For more data on advertised products, use Readers' Service Cards, last page.

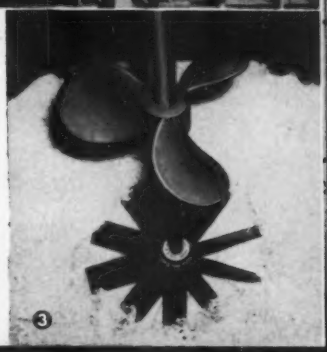
Oil companies throughout the country specify Safety MI Cable for hazardous applications and for remote control and instrumentation. Outstanding design engineers recommend it. One four-part reason...MI's exceptional record of safety, efficiency, permanence and economy. ■ Investigate the many unique characteristics of this versatile cable construction by writing for the new MI catalog

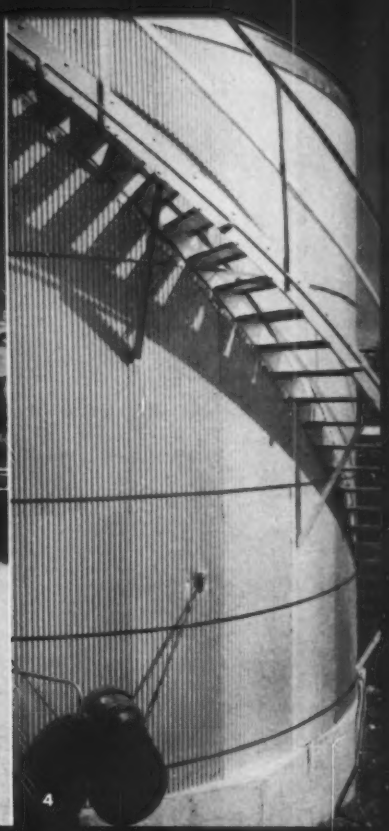
General Cable Corporation

MANUFACTURERS OF MI CABLE SINCE 1941 ■ 730 THIRD AVE., NEW YORK 17, N. Y.



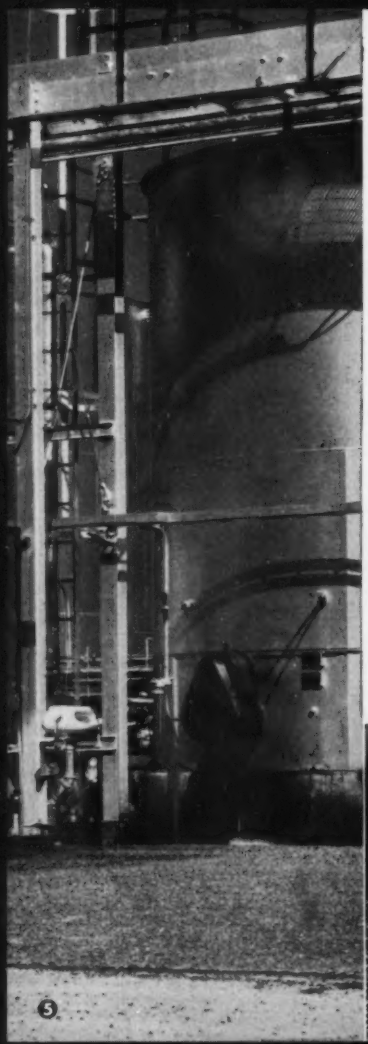






1. Ore purification in pressure vessel with Nettco tank top turbine mixer.
2. Butadiene blending with Nettco side drive mixers having replaceable, mechanical seals.
3. Violent agitation as produced by Nettco's unique combination of turbine and propeller drives.
4. Maintaining product uniformity in Styrene storage tanks with Nettco side drive mixers.
5. Blending with Nettco side drive mixer in storage tank containing 20% caustic solution.
6. Small batch blending with versatile Nettco portable mixer.
7. Standardization of finished product with rugged Nettco vertical turbine mixers.

Improved Processing through Engineered Agitation



WHAT'S THE BEST MIXER FOR YOUR PARTICULAR JOB?

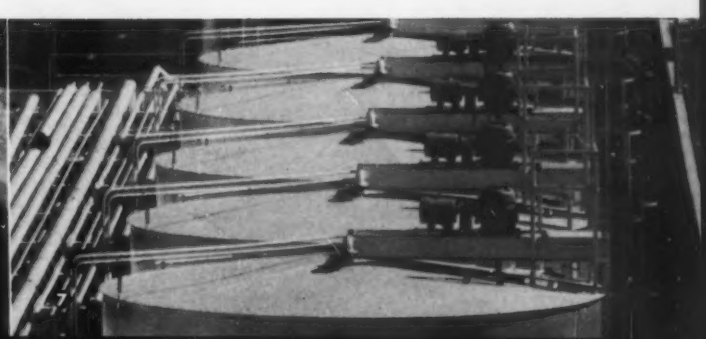
FLUID MIXING demands specialized, highly technical know-how. There is no single mixer which is "best" for every job. Only a mixing specialist can combine and coordinate agitation technology with mixer design and optimum horsepower to achieve an exacting result.

NETTCO ENGINEERED AGITATION provides a full evaluation of all application specifications, an analysis of performance data from pilot runs, and the careful selection of high quality, standard Nettco components to suit the specific job. *You* are assured of the result you want.

BACKED BY A FULL LINE . . . side drive, tank top, portable or tripod and continuous pipeline mixers . . . and thousands of performance-proven installations, like those illustrated, NETTCO can provide invaluable help in determining your fluid mixing needs. See *Chemical Engineering Catalog* or *Refinery Catalog* for our nearest representative, or write for Bulletin 581, NETTCO CORPORATION, 81 Tileston Street, Everett 49, Massachusetts.

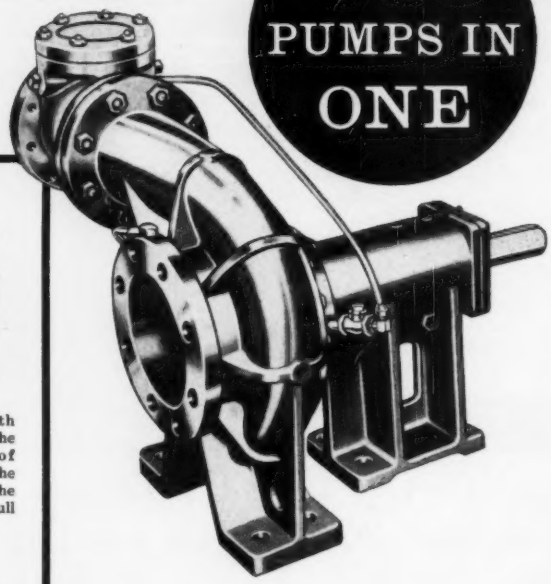
NETTCO

ENGINEERED AGITATION SPECIALISTS

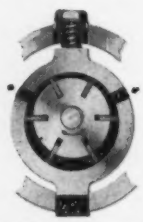


OVERCOME CRITICAL NPSH CONDITIONS WITH ROTO-PRIMES

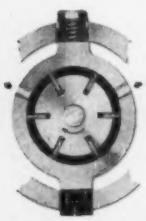
TWO PUMPS IN ONE



Full Priming—With air or vapor in the lines, pressure of spring on top of the movable slide holds the priming pump in full priming position.



Partial Priming—As the pump evacuates air and vapor from the lines, liquid pressure builds up on the underside of the slide, moving it upward toward neutral.



Neutral—When all air and vapor are removed, liquid pressure equalizes spring pressure and the pump automatically slides into neutral...where it remains until air and vapor again appear in the system.

Having trouble with loss of available NPSH when pumping liquid hydrocarbons? Here's your answer — Gilbarco Roto-Prime centrifugal pumps. Roto-Primes are a unique integral combination of a high efficiency centrifugal pump and a variable-capacity positive vane type. Vane pump automatically goes into operation whenever air or vapor enters the centrifugal inlet, providing fast, positive automatic self-priming. These pumps, therefore, *will continue to operate when available NPSH drops below normal requirements.* The 4" x 3" models, as an example, will pump air or vapor from 50 feet of four-inch pipe in less than 60 seconds. Capacities up to 1,600 G.P.M.

Write today for catalog and full information:

Gilbarco

Gilbert & Barker Manufacturing Co.
West Springfield, Mass.
Toronto, Canada

The Mail Box . . .

"Outstanding"

To The Editor:

Will you please have your organization ship me to our Dayton address three copies of your November, 1960 issue of PETROLEUM REFINER.

I want to congratulate you on the very fine piece of work. It's outstanding.

If you will attach your bill for these three copies, I will remit at once.

H. A. Toulmin Jr.

Dayton, Ohio

Erratum

To The Editor:

The report on "How to Blend for Volatility" (October 1960, Page 109) commented favorably on the accuracy of my "$\mathring{P}$ method" for Rvp calculations. However, the equation on Page 131 of the report should be corrected as follows:

$$\sum \frac{V_i \rho_{Mi}}{F + H \mathring{P}_i \gamma_i} (\gamma_i \mathring{P}_i - \mathring{P}) = O$$

where

F-density of the *total blend* in pound-moles per barrel of liquid at 60°F and 1 atm, and *not* for each component, i.

Also, in the second paragraph following the equation, the third sentence reading "Method 5 . . ." should say "The $\mathring{P}$ method . . ."

Warren E. Stewart
The University of Wisconsin
Madison, Wis.

Of Much Interest

To The Editor:

We enclose our check covering ten copies of the November 1960 "PETROLEUM REFINER."

This issue created considerable interest with our personnel at Orange. We appreciate your assistance in obtaining the extra copies.

G. W. Settles
Spencer Chemical Co.
Orange, Texas

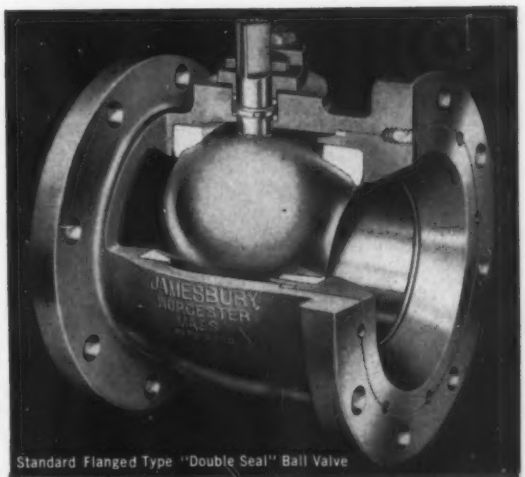
First Helium Plant

To The Editor:

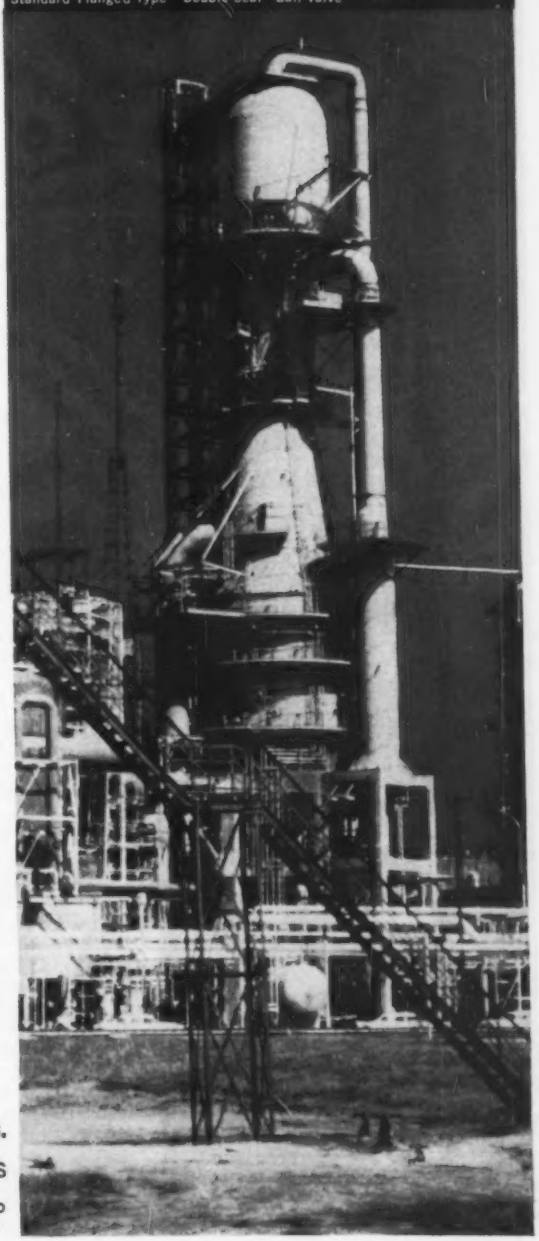
In your February, 1961 issue under "Building" you state that Kerr-McGee Oil Industries, Inc. has started construction on the first privately financed helium

A Significant Announcement to the Refinery and Petrochemical Industries

jamesbury "Double-Seal"™ TYPE DZ FIRE*SAFE†™ BALL VALVES*



Standard Flanged Type "Double Seal" Ball Valve



Available for application in a wide range of installations in the heart of the refinery processing areas and in petrochemical and natural gasoline processing services.

Proved in long-term pre-testing and in full scale processing installations, the Jamesbury "Double-Seal" FIRE SAFE Ball Valve brings the advantages of full flow, quarter-turn positive shut-off, low torque and no lubrication to "the heart of the process" in these industries.

Complete size range and materials data available on request.

Write for Jamesbury Refinery Brochure for further details.

JAMESBURY CORP.

90 New Street, Worcester, Mass.

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*PATENTED
†pat. app. for

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SADI
VALVE OPERATORS
Adaptable to NEW and EXISTING VALVES

THOUSANDS of operators in service throughout the world, typical examples of SADI power transmission equipment quality

SADI
HAULAGE CAPSTANS
TRANSPORTABLE
ECONOMICAL
DEPENDABLE

SADI S.P.R.L.
4, RUE CARBURANTS
BRUSSELS 19 — BELGIUM

Letters . . .

extraction plant to be built in the United States. If my memory serves me correctly, The Helium Company, a subsidiary of The Girdler Corp. of Louisville, Kentucky, (lately merged with National Cylinder Gas Co.), built two such helium extraction plants, privately financed, one in Dexter, Kans. in 1929 or 1930 and a second in Thatcher, Colo. These facilities were later sold to the federal government since it was found that it was impossible to compete with a government owned plant when the government was the major consumer and, by law, had complete control over the production of helium as well as the sale. These plants were designed by R. R. Bottoms, who, incidentally, was also the discoverer of the ethanolamine extraction of H_2S and CO_2, also a Girdler Corp. process known as "Girbotol."

I have a somewhat personal knowledge of this since my first summer job, while going to Rensselaer Polytechnic Institute during the depths of the depression, was helping build the extraction column for a helium recovery plant (at NRA rates of 50 cents per hour) in the shops of Tube Turns, Inc. in Louisville, Ky.

W. D. Luening, Manager
Sinclair Refining Company
Hartford, Ill.

Editor's note. We are happy to know this. Our source of information was solely Kerr-McGee's release.

Valve Safety

To The Editor:

I would like to call your attention to several errors in the article "Relief Valve or Rupture Disc" in the October 1960 PETROLEUM REFINER:

The combination of relief valve with rupture disc under it, (Figure 3, Page 159) is commonly used with noxious gases (chlorine for example) *but* a weep hole is used between the two elements, or preferably, a pressure gauge. Should a pinhole develop in the rupture disc as illustrated, the tank pressure will equalize above it and when a *sudden* pressure surge comes on the system, it will take the set pressure of the rupture disc plus the spring loaded valve to vent the system.

The Figure 4 arrangement is subject to a similar criticism — leakage of the spring loaded valve is a certainty and the pressure between it and the frangible disc will be the same as the tank pressure. With a sudden rise of pressure, the relief pressure will be the *sum* of the set pressure of the two valves.

No mention is made of the fact that frangible discs sometimes burst at much lower than their set pressure, when exposed for a long period of time. For example, a CO_2 tank with two spring loaded reliefs set at 275 and 300 psig, plus a frangible disc at 450 psig let go at 300 psig when the tank was held at no more than 250 psig for about a year. No corrosion is involved as the CO_2 was dry.

Frangible discs on compressed gas cylinders, for example, have to be periodically changed to combat this trouble, but even so, this is not a perfect solution by any means.

It boils down to this, on *noxious gases*, or *where you cannot* stand the loss of the tank contents, a shut-off valve under the relief valve must be used. To avoid accidental closure with resultant non-protection, a 2-way valve is usually used so that one or the other (but not both) valves will provide protection. This will permit periodic servicing of the valves without emptying the tank.

H. A. Sommers
Pennsalt Chemicals Corp.
Philadelphia

Author's Comment

With regard to Paragraph 2, I certainly agree with Mr. Sommers that a weep hole and preferably a pressure gauge should be placed between a rupture disc and relief valve combination.

The Figure 4 arrangement is not intended for handling a sudden rise in pressure, but only the normal action of a relief valve. Rupture disc is placed downstream purely for non leaking purposes. A separate rupture disc would be placed on the vessel for a sudden rise in pressure. Also, it is very true that rupture discs do tend to weaken because of several reasons. Primarily, these reasons include operating too close to the rupture pressure and also the corroding effects of the process fluid. For this reason, depending upon the application requirements, the discs should be replaced, even if they have not ruptured, anywhere from several weeks to several months. Only by experience can one tell how frequently they should be changed. Some companies make a practice of changing them on a definite time schedule, and checking out the rupture pressure of the disc taken out of service purely for experimental purposes.

Concerning the use of a two-way valve, I cannot understand what Mr. Sommers means. If he means that two separate valves should be used in the system, this sounds reasonable. Actually, in many applications wherein a very dangerous liquid or vapor is involved, so that periodic servicing of the relief valve or rupture disc is a necessity, a dual system of relief valves and rupture discs are installed. In this way, one system can be valved off so that inspection or repair can be made on it while the other system offers the protection required.

Mr. Sommer's questions are certainly worth bringing up and I hope that my answers will be satisfactory.

Peter A. Puleo

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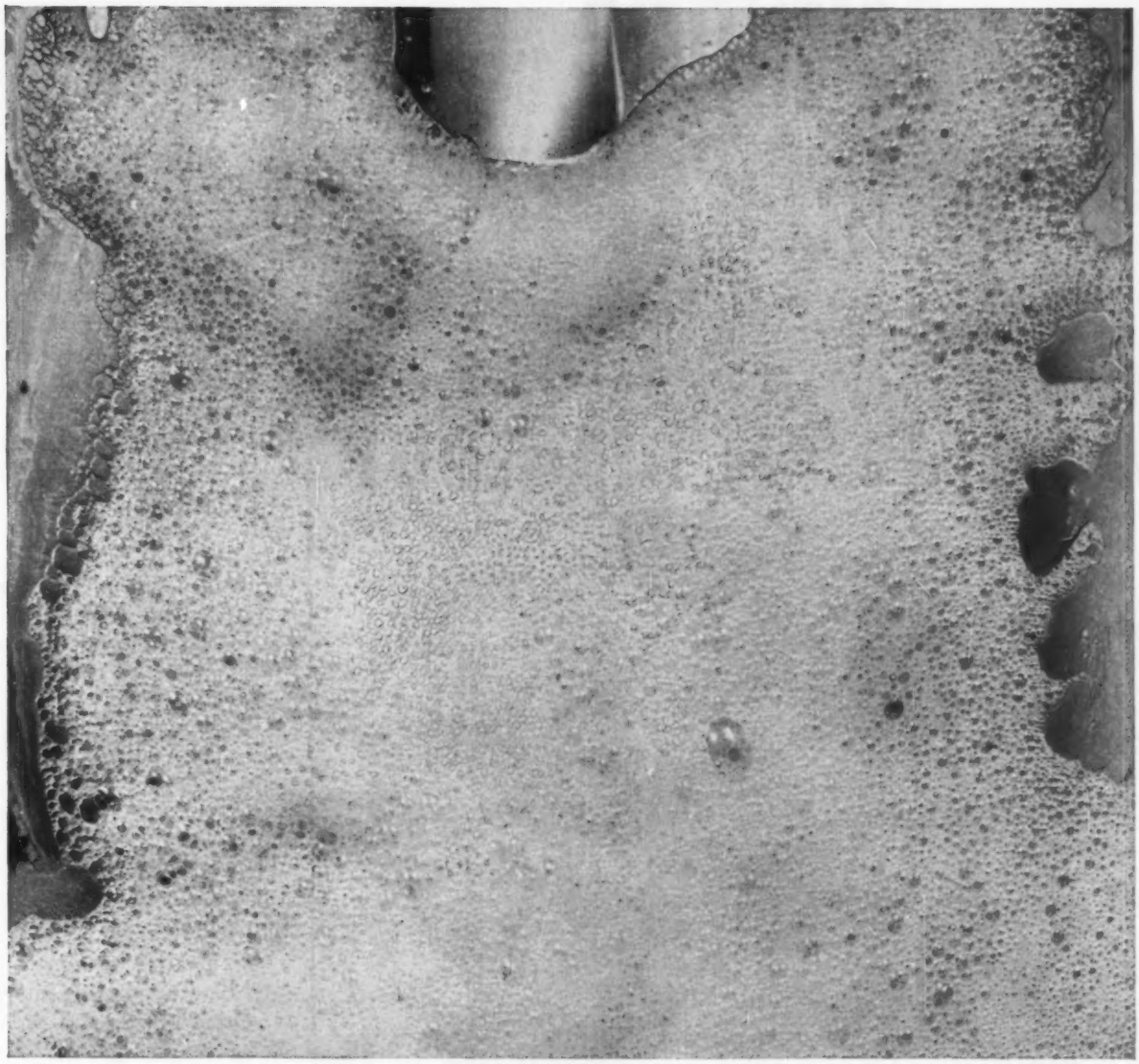

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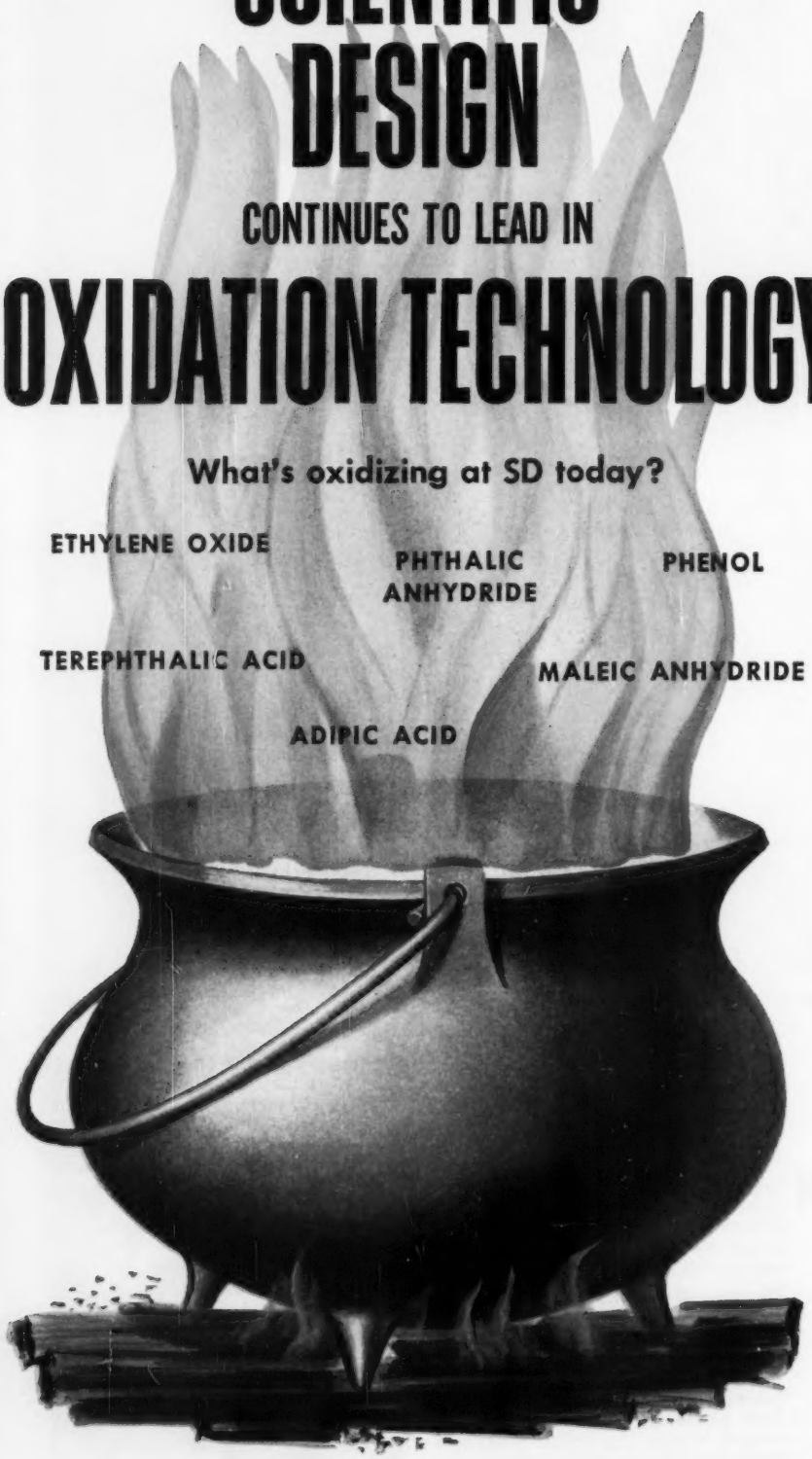

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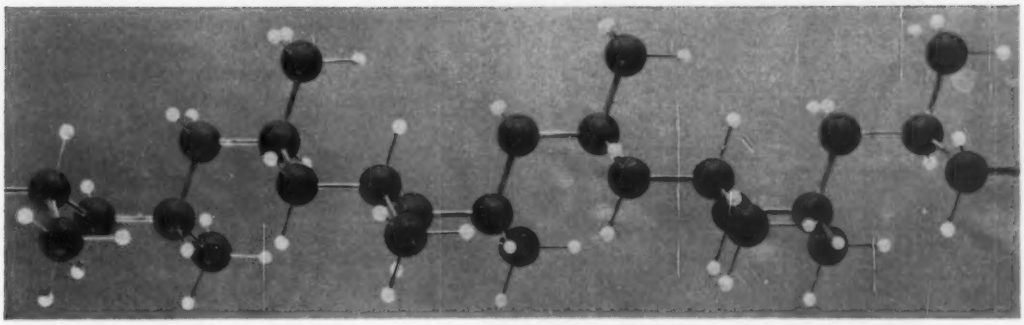

New Uses Spark Propylene Growth

Steady pace of established uses plus exceptional growth of new products can mean unusual demand for high-purity propylene

Thomas, C. Ponder, Petrochemicals Editor, PETROLEUM REFINER

Propylene, one of the first petroleum raw materials used in chemical manufacture, is being studied by petrochemical manufacturers as though it were a new discovery. This exciting new look at propylene is due to the development of several new processes into commercial production.

Such new processes (based on propylene) for acrolein and acrylonitrile justify continuing research into more uses for this versatile raw material. The promise of a rapid acceptance and unusual growth rate for polypropylene adds further to this renewed interest in propylene.

Availability. Sufficient propylene is readily available for any increases in chemical demand, based on an estimated total propylene production of 21 billion pounds per year.[1] Chemical consumption of propylene in 1959 amounted to 2.45 billion pounds which was only 12 percent of this total supply.*

However, this appearance of ample propylene supplies could prove false since increased demand could occur in localized areas and affect only certain petroleum refiners. A further complication for propylene suppliers is that many of the newer derivatives, such as polypropylene, require a relatively pure raw material stream (99+ percent). Not only must a propylene-rich stream be diverted from polymer gasoline production, but distillation capacity is needed for purification. This latter factor in particular could upset refinery operations if there were much variation in chemical offtake.

Distribution. The 1959 percentage distribution and the propylene-ratio for the more established chemicals are shown in Table 1. These data are taken from U.S. Tariff Commission reports and common industry practices. Propylene dichlordie, isopropanolamine, acrolein, allyl alcohol, tridecyl alcohol, and propylene pentamer are

* Portions of this article are based on data which appeared in the November 1960 "Chemical Economics Handbook" published by Stanford Research Institute, Menlo Park, Calif.

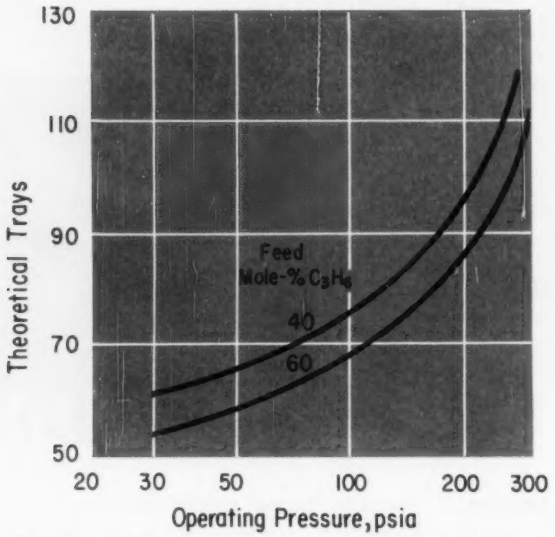

FIGURE 1—These theoretical tray requirements for propylene-propane separation are based on an operating reflux of 1.2 times minimum.

among the remaining propylene derivatives which have attained commerical status. Their combined effect on propylene consumption is rather small and is not expected to increase in importance sufficiently in the near future to effect this consumption materially. There are two propylene derivatives which, although not commercially produced during the time period covered by the reference data, should be of some future importance. These are:

Acrylonitrile. Early in 1960 propylene began competing with ethylene and acetylene as a raw material for the production of acrylonitrile. Because acrylonitrile production capacity presently exceeds demand by a fair amount, propylene for this petrochemical will depend upon the growth and development of more uses for acrylonitrile.

Table 1—Chemical Consumption of Propylene—1959

	lbs. Propylene/ lb. Product	Yield Percent	MM lbs. Propylene	Percent of Total
Cumene	0.41	85	88	3.6
Dodecene	1.27	79	714	29.1
Dodecylbenzene	0.91*	75*	554	(22.6)
Dodecylphenol	....	..	62	(2.5)
Export	....	..	98	(4.0)
Epoxy Resins	0.22	..	12	0.5
Glycerine	0.62	73	81	3.3
Isopropyl Alcohol	0.93	75	1,048	42.7
Nonene	1.21	82	149	6.1
OXO Chemicals	....	..	81	3.3
Isooctyl Alcohol	0.58	..	31	(1.3)
Butyraldehydes	....	..	50	(2.0)
Polypropylene	1.05	..	21	0.9
Propylene Oxide**	0.9	..	259	10.8
Propylene Glycol	0.72	75	109	(4.4)
Dipropylene Glycol	0.90	70	21	(0.9)
Polypropylene Glycol	0.90	78	11	(0.4)
Polyurethanes and other	....	..	102	(4.2)
By-Product propylene dichloride	....	..	16	(0.7)
Total			2,453	

* Yield from dodecene.
** Includes byproduct propylene dichloride at rate of 0.13 pounds per pound of oxide.

Ethylene-Propylene Copolymer. Montecatini in Italy has carried out extensive development work with this polymer and claims it has excellent elastomer properties. Recently, interest has been expressed in producing this material in the United States. It is too early to speculate on the importance that this elastomer will have as a propylene user.

Propylene Sources. Propylene is obtained from two principal sources. It is recovered from refinery off-gases (from catalytic of thermal cracking of petroleum) and as a byproduct of ethylene manufacture (from cracking of propane, butane, or heaiver oil stocks).

Propylene from off-gases or from propane cracking is recovered as a mixture containing 35-60 percent propylene. Cracking of butane and heavier materials gives 90+ percent propylene.

Another possible source of propylene which could become commercial is the catalytic dehydrogenation of propane. This technique is currently used to a large extent for the production of butylenes and butadiene from normal butane. Propane dehydrogenation must be operated at much higher temperatures than *n*-butane pyrolysis and involves technical and operating problems which do not appear to have been completely solved. Therefore, this route to propylene faces some economic problems before going commercial.

It would appear that propylene is rather unique in that as a chemical raw material it is produced economically only as a byproduct or a co-product. A company using propylene alone for chemical purposes must resort to purchase from merchant producers or be willing to broaden its activities considerably into other parallel activities such as ethylene-based materials to become basic in propylene.

Propane-propylene mixtures from off-gases are used to manufacture isopropyl alcohol, cumene, nonene, and dodecene. High-purity propylene is used for such derivatives as the oxo chemicals, acrolein, and polypropylene.

PROPYLENE PURIFICATION

The recovery of a propylene-propane stream in a refinery or a chemical plant is conveniently accomplished by means of fractional distillation. Alternate techniques involving selective adsorption and absorption have been studied but do not seem to be of commercial importance. The typical distillation would be carried out in two steps in series, each with 30-40 actual stages and moderate reflux ratios, giving a propylene-propane mixture with less than two percent C_2 and C_4 contaminants.

Volatility ratio, or "relative volatility" can be used as a common index in determining the difficulty of separating two materials by distillation. These values, when calculated from literature data on vapor-liquid equilibria, are low in comparision with many commerical distillation separations. This is particularly true when using operating pressures of 250-300 psia which will permit condensation of reflux with cooling water. Therefore, these physical properties place an initial limitation on the ease of separation by distillation.

Extractive distillation agents may be used to alter the

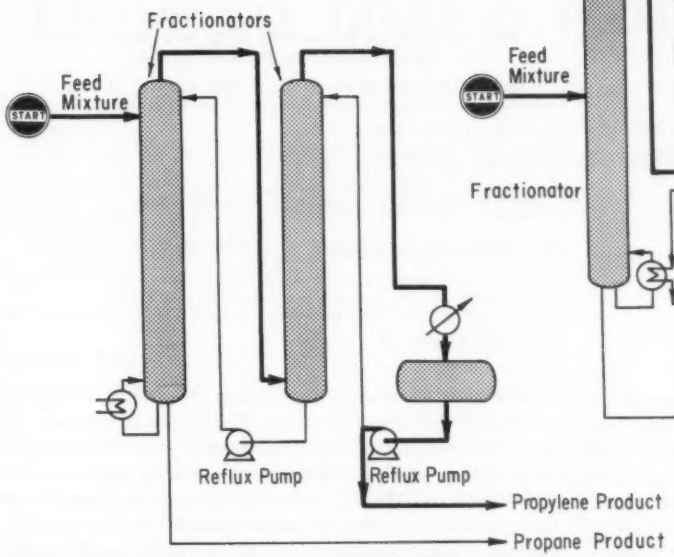

FIGURE 2—In this propylene-propane distillation system, operating pressure must be high enough for cooling water reflux condensing.

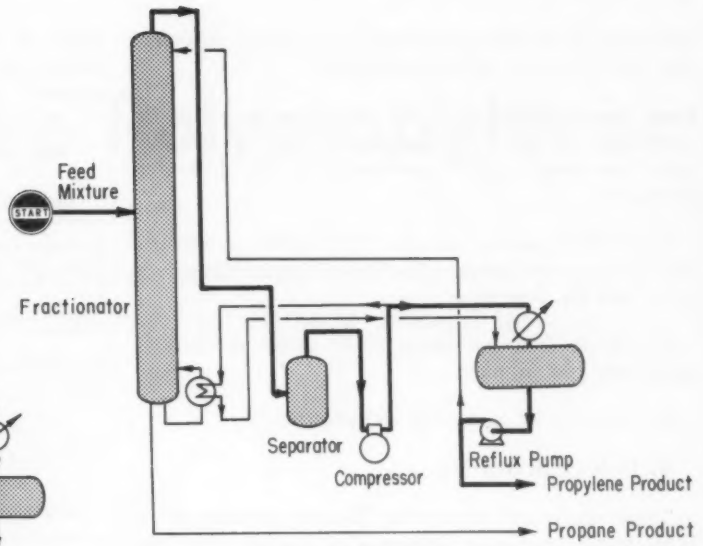

FIGURE 3—This system for high-purity propylene requires a recompression system for condensing reflux but only one tower.

volatility ratio. Table 2 lists several such agents and the corresponding volatility ratios. Note that these materials reverse the normal volatility ratio; the propane-rich stream going overhead and the propylene-rich stream as bottoms. However, it should be pointed out here that the additional expense of handling the extracting agent is not usually justified.

TABLE 2—Solvent Effect on Relative Volatility of Propylene-Propane, 82° F

Solvent	C_3s in Mixture	Volatility, $\frac{C_3H_6}{C_3H_8}$
(None)	100	0.83-0.87
Acetone	40	1.03
Furfural	15-18	1.19
Furfural with 4% water	12-15	1.23
Acrylonitrile	26-34	1.29
Acetonitrile	14-19	1.35
50-50 Acrylonitrile-Acetonitrile	15-25	1.72

Note: These data from Teter, J. W., and Shand, E. W., U.S. 2,588,056.

Another factor in the general problem of C_3 separation is the propylene content of the feed mixture which is to be recovered as high-purity product. These stage requirements are required for a C_3 mixture of 50-percent propylene, 90-percent recovery being equal to 1.00:

Recovery, Percent	Relative Stages
90	1.00
80	0.90
70	0.84
60	0.80

However, for a fixed product demand, throughput rates increase with decreasing recovery, and savings in stage requirements are likely to be offset by larger equipment sizes.

Stage requirements for 90-percent recovery of 99-percent proylene are shown in Figure 1 as functions of operating pressure. The plot is based on reflux ratio of 1.2 times the ratio corresponding to infinite stages, a value found to be near optimum for light hydrocarbon separations. Notice that the effect of operating pressure is quite significant, and possibly a certain amount of refrigeration might be justified for lowering the pressure below that required by cooling water temperature.

Performance tests on propylene-propane fractionators have shown efficiencies in excess of 100 percent. Thus, the stages shown in Figure 1 may be considered as actual trays when following recognized principles of efficient vapor-liquid contacting.

Feed Mixtures of 40-60 Percent Propylene. As shown in Figure 1, operating pressure significantly affects the stage requirement for separating propylene and propane. Thus, when studying the economics of separation by distillation it is convenient to use pressure level as the primary process variable.

Distillation reflux may be condensed by cooling water at pressures on the order of 300 psia. Because of the economics of column height, two columns are usually connected in series as shown in Figure 2. Using data from Figure 1, each column contains 55-65 actual trays.

When operating at 100-200 psia, it is convenient to use a vapor recompression cycle for reflux condensation. Overhead vapor is compressed and then condensed as heating medium for the column reboiler. This arrangement is shown in Figure 3. In this case, the lower operating pressure permits the use of a single column but does require a compressor. In some cases, this compression

operation can be intergrated with a propylene refrigeration system serving other process units.

Cost Comparisions. Cost of upgrading propylene by distillation for operating pressures of 100, 200 and 300 psia have been made, governed by the following premises:

1. 50 MM pounds per year (11.5 billion gallons per year) of propylene produced at 99-mole-percent purity on a C_{2-} and C_{4-} free basis.

2. Liquid feed containing 50-50 molar mixture of propylene and propane.

3. Recovery of propylene—90 percent

4. Gulf Coast location.

These results are compared in Table 3. Although there is no clear-cut optimum pressure level, it is apparent that vapor recompression has some advantage. These results do not consider special or unusual cases of integration with existing process units and service facilities. However, one may conclude that the bare cost premium to be placed on high-purity propylene is about 2.5 cents per gallon. Therefore, if the propylene contained in the feed mixture is worth 6 cents per gallon for poly-gasoline manufacture, the bare cost of high-purity propylene is about 8.5 cents per gallon. To this must be added the usual amounts for profit, general overhead, etc., to obtain a valid sales or transfer price.

Recovery by extractive distillation of high-purity propylene have shown significantly higher costs than those given in Table 3. Direct conversion cost is slightly higher and the manufacturing capital cost about 30 percent higher than for 300-psia distillation. Also, energy requirements for recovery of propylene from the solvent cause an increase of nonmanufacturing capital by about 15 percent over conventional operation. Therefore, detailed figures for extractive distillation operation have not been shown as a competitive case in Table 3.

Table 3—Cost of Recovering 99% Propylene from a 50-50 Propylene-Propane Mixture

Basis: 11.5 MM Gal./Yr. 99% C_3H_6 90% Recovery of C_3H_6

Case	I	II	III
Distillation Pressure, psia	100	200	300
Actual Trays	70	90	120
Tray Spacing, inches	18	16	18
Column Diameter, feet	5.5	6.0	6.5
Compressor Brake Horsepower	1100	500	.....
Conversion Cost, ¢/gal. C_3H_6 product			
Direct[1]	1.50	1.39	1.73
Indirect[2]	0.94	0.84	0.79
Total	2.44	2.23	2.52
Capital Cost,[3] thousands $			
Manufacturing	720	636	520

[1] Includes no item for cost of propylene in feed.
[2] Includes depreciation, local taxes, etc., at 15% of Manufacturing Capital per year.
[3] Battery limits only. Tankage, services and other outside battery limits capital not included.

Feed Mixtures of 90+ Percent Propylene. Upgrading 90-percent propylene to 99-percent purity is best done according to the method shown in Figure 2, but with a single column. Calculations for this scheme are shown in Table 4. These costs are based on 50 MM pounds per year of propylene production and 90-percent recovery.

Table 4—Cost of Recovering 99% Propylene from a 90-10 Propylene-Propane Mixture

Basis: 11.5 MM Gal./Yr. 99% C_3H_6 90% Recovery of C_3H_6

Distillation Pressure, psia	300
Actual Trays	70
Tray Spacing, inches	18
Column Diameter, feet	5.5
Conversion Cost, ¢/gal. C_3H_6	
Direct[1]	1.07
Indirect[2]	0.46
Total	1.53
Capital Cost,[3] Thousands $ Manufacturing	288

[1] Includes no item for cost of propylene in feed.
[2] Includes depreciation, local taxes, etc., at 15% of Manufacturing Capital per year.
[3] Battery limits only.

Although the cost of upgrading 90-percent propylene is considerably lower than for 50-percent propylene, the cost is still significant and must be considered in the light of premium paid for the source cracking material. On the other hand, the C_3 fraction from such cracking operations frequently contain more than 90-percent propylene, and the upgrading cost is correspondingly lower.

POLYPROPYLENE PURITY REQUIREMENTS

The purity requirements for the monomer (propylene) used in the polymerization are quite stringent because of the extreme reactivity of the catalyst used. Oxygen, carbon monoxide, carbon dioxide, water, and sulfur-containing compounds are examples of impurities that must be rigorously excluded from the polymerizer. The presence of other olefins should be avoided since they may have an adverse effect on the polymerization rate. Also, if these olefins can be polymerized by Ziegler catalysts, i.e., ethylene or other alpha-olefins, they may interfere with the regularity of the polymer chain and substantially reduce the polymer crystallinity. These unsaturates are generally removed by acid treatment or hydrogenation.

It is apparent from study of patents on various polypropylene processes that high-purity propylene is essential. From a casual survey of propylene upgrading, it is also apparent that high-purity propylene is not inexpensive. While 99-plus percent propylene is generally thought to be valued at somewhere between 1 to 1.5 cents per pound less than comparable purity ethylene, these prices would require careful study before basing plants on these values. Because of the close association of byproduct propylene with fully integrated plants, actual transfer prices are extremely difficult to calculate.

The usual economics associated with increasing demand and building of larger plants will have its effect on high-purity propylene price. If polypropylene exceeds the expected growth for a new polymer, there could be some sharp trading and shifting for raw materials used in the manufacture of the better established products shown in Table 1.

LITERATURE CITED

[1]Hatch, L. F., Petroleum Refiner, Vol. 38, No. 8, August 1959, p 107.

How to Make Polypropylene

Here are the important operating conditions, catalysts, processing techniques and product recovery methods essential to successful polymer manufacture

Marshall Sittig,
Princeton, N.J.

Polypropylene is definitely the polymer in the news. It is now undergoing the explosive growth which has been characteristic of polyethylene in the last five years.

The world's first commercial polypropylene was produced in September of 1957 at the Ferrara, Italy works of Montecatini. Polypropylene was developed by Dr. Guilio Natta at the Milan Polytechnic Institute, working under a grant from Montecatini, and based in part on the work of Karl Ziegler in Germany. Farbwerke Hoechst was also early in European production of polypropylene.

The first United States production of polypropylene was by Hercules Powder Company. Since then, Avi-Sun has joined the ranks of United States polypropylene producers as has Humble Oil & Refining Co.

Now, polypropylene and its sister polyolefins have been the subject of books by Kresser,[16] by Sittig,[27] and by Topchiev and Krentsel[28] as well as by Gaylord and Mark.[12] Other reviews dealing specifically with polypropylene have been published by Repka and Harris[25] and by Goppel.[14]

WHAT IS POLYPROPYLENE?

Polypropylene means many things to many people. In the periodical and patent literature, you find references to "polypropylene" when propylene trimers or tetramers (as used in polymer gasolines or as detergent intermediates) are really designated. Then, of course, propylene can be polymerized to lubricating oil fractions or to even heavier greasy materials which can indeed be used as greases or as lubricating oil additives.

Primarily, though, polypropylene means a solid polymer of propylene having a substantial degree of crystallinity; it was the first such olefin polymer containing asymmetric carbon atoms in the principal chain of the macromolecule. Although regularly arranged which allows for the possibility of crystallizing, commercial "isotactic" polypropylene is only about 60 percent crystalline, as compared to 95 percent crystallinity for high-density polyethylene. As pointed out by Goppel,[14] this lesser degree of crystallinity results in increased transparency of polypropylene over polyethylene.

A typical polypropylene of commercial utility may have about 1,000 propylene units in the typical polymer chain, giving a molecular weight of 42,000, although polypropylenes having much higher molecular weights can be prepared.

Recently, syndiotactic (regular but alternating in steric arrangement) polypropylene has been synthesized by Natta and his co-workers[24] directly from propylene and free of isotactic crystallinity. Such a polymer has a chain formation which allows very good packing; this leads to a melting point even higher than that of isotactic polypropylene. The thermal and mechanical properties of these syndiotactic polypropylenes may offer interesting promise for future application.

Polypropylene is the lightest of all commercial plastics (specific gravity = 0.90); it has a high melting point (168-171°C for the isotactic polymer) and has a higher tensile strength and greater rigidity than high-density polyethylene. Polypropylene is also characterized by excellent dielectric properties, low creep, and a lustrous surface highly resistant to acid, solvent, and chemical attack. This combination of properties makes polypropylene useful in a wide variety of molding, extrusion, film and fiber application. This has led many companies to attempts to develop a dominant patent position in the manufacture of this new material.

THE CONFUSING PATENT PICTURE

Although Professor Natta was responsible for the first isotactic polypropylene with his rights assigned to Montecatini, the patent picture (in the United States, at least) does not now clearly support this. There are Montecatini patent applications before the United States Patent Office and have been for about six years but only a bare scattering of United States patents have been issued to Natta and Montecatini. In foreign countries, such as Japan[4] and Sweden,[10] there have been basic patents issued to Natta-Montecatini and other companies are either willingly operating under license[5] or are the subject of legal action attempting to force them to do

so.[4] Montecatini license agreements have also been signed by Imperial Chemical Industries in England, by Royal Dutch Shell in Holland, by Pechiney and Societe Normande de Matieres Plastiques in France and by Danubia Petrochemie, A. G. in Austria[5] as well as by Esso Svenska in Sweden.

As of November 1959, however, there were 209 foreign patents on polypropylene processes, catalysts and engineering.[7] See Table 1.

TABLE 1—Foreign Polypropylene Patent Box Score
(Firms Having 10 or More Patents by November 1959 Only)

Firm	Australia	Belgium	6 Other Countries	Total
Phillips Petroleum	23	23	14	60
Montecatini	2	10	7	19
Ruhrchemie A. G.	0	9	7	16
Badische (B.A.S.F.)	0	5	7	12
Union Carbide	4	0	7	11
Farbwerke Hoechst	0	6	4	10
Imperial Chem. Ind.	2	4	4	10
All Others	4	41	26	71
Totals	**35**	**98**	**76**	**209**

In the United States no company has yet received a composition of matter patent on isotactic propylene corresponding to the DuPont patent on linear polyethylene (U.S. 2,816,883), which is now the subject of litigation.

COPOLYMERS

Just as copolymers have become important in the polyethylene field, so do they show signs of significant development in the polypropylene field.

According to Mark and Atlas,[18] a polyethylene species which represents the optimum compromise of rigidity, heat distortion, solvent resistance and stress cracking characteristics can be best produced by introducing 2-3 percent of propylene. They go on to state, however, that polymers containing small percentages of ethylene in isotactic polypropylene have also been prepared and examined but do not show any properties which could make them attractive for practical application.

Elastomers from Ethylene and Propylene. At the Milan Trade Fair in 1959, Montecatini exhibited the first samples of a new synthetic material which had elastomeric properties approaching those of natural rubber and, in some cases, better than those of conventional synthetics.[6] It was then stated to be in production in a pilot plant at Ferrara, Italy. In contrast to polypropylene resins, this rubber is completely amorphous.

These ethylene-propylene copolymer elastomers have properties which are generally midway between natural rubber and butadiene-styrene coplymers. The low specific gravity of the propylene copolymer (0.85 - 0.86 gm/cc) offers the possibility of lowering the cost of articles on a volume basis, however. More important, perhaps, is the saturated, chemically-inert nature of the propylene copolymer which imports outstanding resistance to heat, oxygen, ozone, etc.

These materials contain perhaps 30 - 70 moles of ethylene and 70-30 moles of propylene. They are best prepared using catalysts made up of VCl_4 plus $VOCl_3$, together with trihexyl and triphenyl aluminum. Hydrogen can be used to control molecular weight.

Hercules Powder Company and U.S. Rubber have recently announced intentions of commerical production of these elastomers, following on the announcement of a 20,000 ton-per-year plant at Brindisi, Italy, slated by Montecatini to go on stream in 1962.

Copolymers of Propylene with Other Olefins. Certain copolymers of propylene and butene-1 have very low brittle points as compared to pure crystalline polypropylene and yet are comparable in strength and melting point. Mixtures containing from 7 to 25 percent of butene-1 are particularly desirable as indicated in Table 2. It is interesting to note that copolymerization of propylene with other olefins does not give comparable copolymers. For example, copolymers of propylene with butadiene, ethylene, cyclohexene, 4-vinyl cyclohexene and styrene yielded copolymers which were either too brittle, or which were defective by reason of lowered tensile strength or lowered melting points.

TABLE 2—Effect of 1-Butene Content on Propylene Copolymers

Percent 1-Butene	POLYMER PROPERTIES		
	Mole. Weight	Melting Pt., °C	Brittle Pt., °C
0	210,000	165	+13
3	169,000	150	+ 7
10	107,000	155	— 4
25	60,000	...	— 3

Copolymers of propylene with norbornene (bicyclo-(2, 2, 1)-2-heptene) are characterized by good melt flow properties which allow their ready fabrication by melt extrusion techniques and injection molding techniques into films, fibers, and other shaped articles. At high bicycloheptene contents, stiff polymers are obtained; at low bicycloheptene contents, soft and elastic compositions are obtained. Particularly outstanding properties are obtained at bicycloheptene contents of 1 to 10 percent; such polymers have good toughness at low temperatures and show X-ray crystallinity, permitting improvements of mechanical properties through orientation (U.S. 2,934,527).

Copolymers of Propylene with Dienes. Some work has been reported[2] by workers at the Dunlop Research Centre at Toronto, Ontario, Canada on copolymerization of propylene with isoprene using a cationic, Lewis acid type catalyst such as $AlCl_3$, $TiCl_4$, BF_3 and $AlBr_3$ in an ethyl chloride solvent. Although immediately useful elastomers were not obtained, resins and rubbery polymers having molecular weights of 6,000 to 10,000 were obtained. These copolymers had isoprene contents as high as 50 percent which was significant because Butyl rubber, by comparison, contains only 5 percent isoprene and such high diene incorporation in an olefin polymer was heretofore unknown using such cationic systems. The high degree of unsaturation in these materials may be valuable in providing sites for further processing.

Terpolymers. Wever and his co-workers at Chemsche Werke Huels in Germany have polymerized ternary

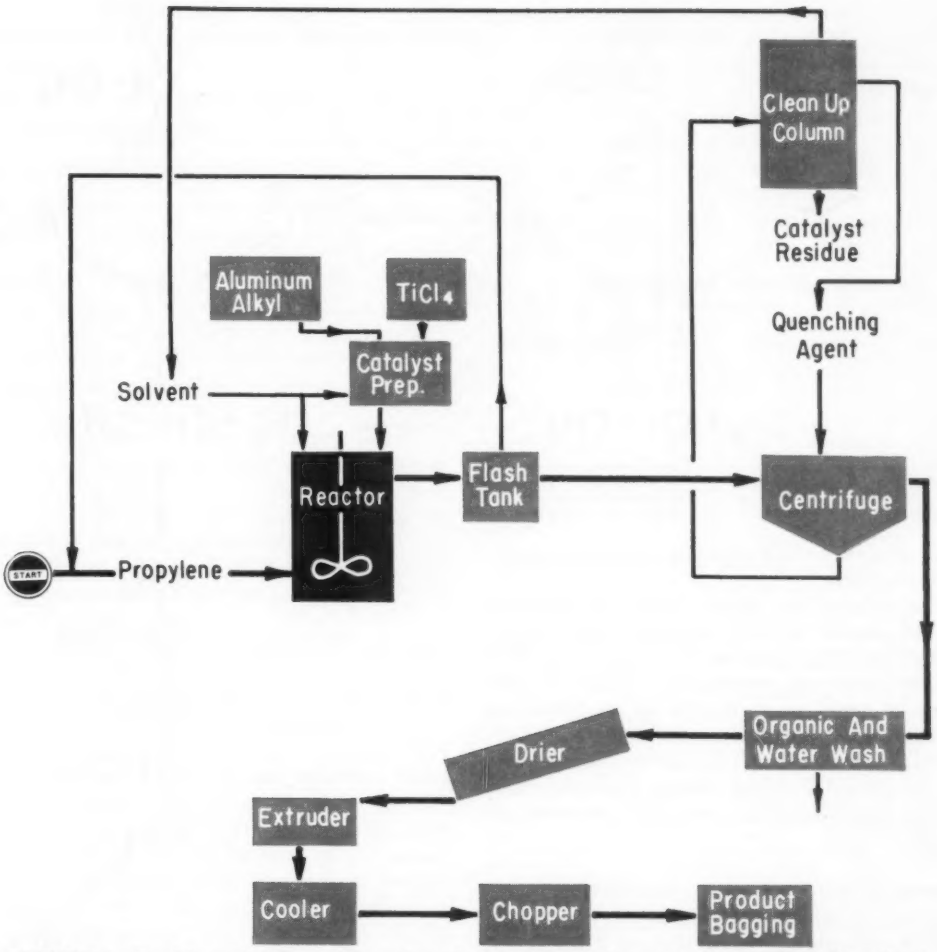

FIGURE 1—In this typical propylene polymerization scheme the reactor is charged with solvent, the catalyst added as a slurry, and the propylene fed in at a controlled rate. When reaction slurry becomes 20-40 percent solids the mass is run to a flash tank where catalyst is quenched. Further treatment frees the polymer of catalyst after which it is washed, dried and ground for shipment.

mixtures of ethylene, propylene, and butadiene.[3] One such polymer contained 75 percent ethylene, 20 percent propylene and 5 percent butadiene and was prepared using a catalyst containing 25 percent $TiCl_4$, 25 percent VCl_4 and 50 percent triethyl aluminum. The butadiene contents of such polymers have been below 10 percent and the ethylene-to-propylene ratio has run from 70/30 to 30/70.

OPERATING CONDITIONS

Polymerization of propylene can be carried out in batch or continuous operation.[17] The reactor is charged with solvent, the catalyst is usually added as a slurry, and the propylene is fed in at a controlled rate. The exothermic heat of reaction is removed, usually by a heat transfer jacket. Propylene addition is continued until the reaction slurry becomes quite thick (20-40 percent polymer solids). The mass is then run to a second vessel where the active catalyst is "quenched." The polymer is then freed of catalyst by further treatment and dried preparatory to shipment. A typical flow diagram for polypropylene manufacture is shown in Figure 1.

Pressure. All polypropylene produced today is produced by "low-pressure" processes. This is in contrast to polyethylene where "low-pressure" processes are the subject of much exciting development but where the king's share of actual production is carried out at high pressure (over 1,000 psi). By low pressure, we mean 1-40 atm (15-600 psi).

Production at substantially atmospheric pressure has, of course, a number of advantages over high pressure operation. These include

1. Lower equipment cost
2. Greater safety in operation
3. More ready adaptability to a continuous process.

Since increased pressure increases reaction rate, a balance must obviously be struck in picking the optimum operating pressure. Molecular weight is essentially

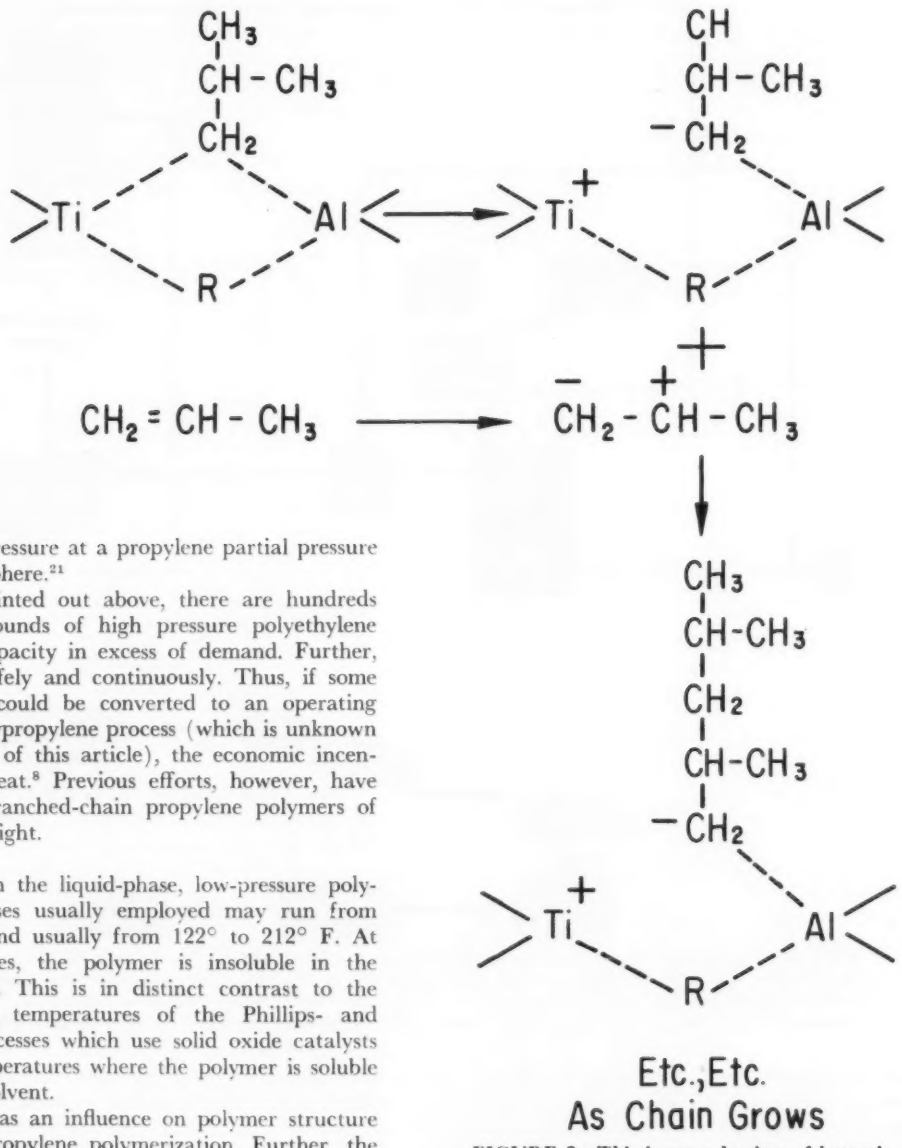

FIGURE 2—This is a mechanism of isotactic polypropylene formation as depicted by Natta.[23] In this proposed mechanism, the polymer builds upon a bridge bond between the two metals present.

independent of pressure at a propylene partial pressure above one atmosphere.[21]

Further, as pointed out above, there are hundreds of millions of pounds of high pressure polyethylene capacity—and capacity in excess of demand. Further, it is operating safely and continuously. Thus, if some of the capacity could be converted to an operating high-pressure polypropylene process (which is unknown as of the writing of this article), the economic incentive would be great.[8] Previous efforts, however, have produced only branched-chain propylene polymers of low molecular weight.

Temperatures in the liquid-phase, low-pressure polypropylene processes usually employed may run from 68° to 248° F and usually from 122° to 212° F. At these temperatures, the polymer is insoluble in the reaction medium. This is in distinct contrast to the higher operating temperatures of the Phillips- and Indiana-type processes which use solid oxide catalysts operating at temperatures where the polymer is soluble in the reaction solvent.

Temperature has an influence on polymer structure in the case of propylene polymerization. Further, the effect differs when $TiCl_4$ is used as the catalyst from the effect exhibited when $TiCl_3$ is used as the catalyst.

Reaction Time. Polymerization times are commonly in the range from one-half hour to ten hours, although Labine[17] states that residence time in the reactor in the Esso process is believed to be much shorter.

Reaction rate is independent of time in polymerizations using $TiCl_3$-AlR_3 catalysts, at least after an initial period.[20] Further, the rate was found to be independent of aluminum alkyl concentration but dependent on

- Propylene concentration
- $TiCl_3$ concentration
- Temperature
- Method of $TiCl_3$ preparation (degree of subdivision and temperature and solvent used in the preparation step)—particularly in the initial stages of polymerization.

Solvent. Hydrocarbon diluents such as *n*-heptane have commonly been used as solvents in polypropylene manufacture. The polymer precipitates from such a solvent as it is formed. Systems in which polypropylene would be soluble have been found to produce largely amorphous polymer according to Harban and his associates.[15]

Degree of Agitation. It has been reported by Sherwood[26] that increased polymer molecular weight results from improved reactor agitation.

CATALYSTS

The requirements of a top-notch polypropylene catalyst include:

1. Ability to control polymer structure to produce high stereospecificity
2. High polymerization rate
3. High efficiency—i.e., low ratio of catalyst required to polymer produced
4. Adaptability to operation at high conversions
5. Ease of removal from polymer product.

The catalyst art in the polypropylene field is indeed complex as pointed out in a recent book.[27] Generally speaking, catalysts for the preparation of polypropylene contain a Group IV metal such as titanium in an intermediate valence state. This subhalide may be produced in situ by reaction of $TiCl_4$ with a reducing agent such as an aluminum alkyl or may be preformed in a separate reaction vessel and separated prior to introduction to the polymerization reactor.

Electrical discharges may be used in the production of the preformed subhalide catalyst as disclosed both in the United States and Japan.[1]

More generally, polypropylene catalysts are prepared by the reaction of compounds of strongly electropositive transition metals with organometallic compounds based on the first three groups of the periodic table.

The solid catalysts thus obtained contain active sites which are able to control the monomer addition. Each new monomer molecule takes a position on the site identical (head-to-tail) with that occupied by preceding molecules which have now been incorporated in the polymer chain. Thus the polymer chain unreels from the catalyst surface like a fishing line from a reel. The repetitive regularity in structure allows the polymer to crystallize for substantial sections of the polymer chain. Present commercial grades of polypropylene vary in crystalline content from 55 percent to 65 percent of the polymers by weight, based on X-ray measurements.

The actual mechanism of polymer formation has been the subject of learned dispute. Some investigators have postulated that the polymer chains grow on titanium. While conceding that such a mechanism may sometimes be operative (when a titanium tetraalkyl-titanium tetrahalide catalyst is used), Natta[23] feels that polymers so formed are definitely of a lesser degree of isotacticity than those formed from catalysts containing both aluminum and titanium. Natta goes on to depict the mechanism as shown in Figure 2. In this proposed mechanism, the polymer builds upon a bridge bond between the two metals present.

Depending on the method of catalyst preparation and on the amount and nature of the components used, various types of polymer are actually formed in all cases.

1. A highly crystalline isotactic polymer which is insoluble in boiling heptane
2. A completely amorphous atactic polymer which is soluble in ether
3. An intermediate fraction which is of intermediate crystallinity and which is probably a stereoblock polymer (having a chain containing both atactic and isotactic segments).

The best catalyst is usually that which produces the maximum of the first variety above.

The essential ingredient of many polypropylene catalysts is titanium trichloride. $TiCl_3$ is not a simple compound, however; it exists in various forms as shown in Table 3.

TABLE 3—Types of Titanium Trichloride

Designation	Color (& Crystal Form)	Preparation	Comments
Alpha	Violet (hexagonal)	Reduction of $TiCl_4$ with H_2 at high temperatures. or reduction of $TiCl_4$ with Ti metal at 400° C.	Shows high stereospecificity. (Polymer 80–90% insol. in boiling heptane.)
Beta	Brown (a linear polymer of $TiCl_3$)	Reduction of $TiCl_4$ with H_2 in electric discharge. or reaction between $TiCl_4$ and AlR_3 in equimolar quantities. or decomposition of $TiCl_3 \cdot CH_3$ in hydrocarbon solution.	Polymer 40–50% insol. in boiling heptane.
Gamma	Violet (cubic)	Heating beta form to 250–300° C for 2–3 hours in an inert atmosphere. or decomposition of $TiCl_3 \cdot CH_3$ in absence of a solvent.	Polymer as stereospecific as from alpha form.
Delta	Violet (partially disordered)	Reduction of $TiCl_4$ with aluminum metal. Product contains $AlCl_3$ in solid solution.	Polymer of stereospecificity equal to or greater than that from alpha form; Highest reaction rate of any form.[24A]

There is the statement in the patent literature[27] that $TiCl_3$ alone is inactive in propylene polymerization. The answer seems to be that $TiCl_3$ alone is inactive but that $TiCl_3$ in the presence of even a trace of an aluminum alkyl or other activator is active. However, it has been claimed that $TiCl_3$ alone is an active catalyst when used in the presence of ultrasonic waves.

The violet form of $TiCl_3$ is preferred in some work on propylene polymerization but some Esso patents claim that more severe polymerization conditions are required to produce polypropylene using the violet salt than are the case when the brown salt is used. However, all seem agreed that the violet forms produce a higher percentage of stereospecific propylene polymer than does the brown (beta) form.

There are commercially available today both a hydrogen-reduced and an aluminum-reduced form of $TiCl_3$. The hydrogen-reduced variety is 98.5-99.9 percent $TiCl_3$ and the aluminum-reduced form is essentially pure $AlCl_3 \cdot 3\ TiCl_3$.

The use of a $TiCl_3$-$AlEt_3$ catalyst rather than a $TiCl_4$-$AlEt_3$ catalyst has the following advantages in terms of polymer properties:

1. Higher crystallinity—confirmed by X-ray measurements and specific gravity figures
2. Higher softening and melting points

3. Increased strength (a 3-fold increase in tensile strength)
4. Less extensibility
5. More rigidity (higher modulus of rigidity values)
6. Lower permeability to vapors and gases such as water vapor.

Another catalyst system than the usual Ziegler-Natta type has been claimed by Bier of Farbwerke Hoechst,[11] who states that high stereospecificity of product and several-fold greater activity are features of his catalyst.

A wide variety of catalyst combinations have been patented as useful in propylene polymerization as shown in Table 4.

TABLE 4—Some Catalysts Proposed for Producing Polypropylene

Component A	Component B	Component C	U.S. Patent Reference
$TiCl_4$	$AlCl_3$	$P(OR)_3$	2,962,487
.....	Li	.....	2,962,472
$TiCl_3$	Li	.....	2,962,472
$TiCl_3$	$C_5H_{11}Na$	$PO(NR_2)_3$	2,958,688
$TiCl_4$	$AlR_3 \cdot RO$ Ar	.....	2,956,992
$(TiCl_4 + AlEt_2Cl)$	$AlEt_3$	.....	2,954,367
Diphenyl-bis-cyclo-pentadienyl-Ti	AlR_3	.....	2,952,670
$TiCl_3$	$R_3Al_2X_3$	R_3 (N, P, As, Sb)	2,951,066
$TiCl_4$	Al	Ti $(OR)_4$	2,948,712
TiX_4	Al	Pt or Pd	2,945,845
.....	$R_3Al_2X_3$	Al	2,945,018
$TiCl_4$	RNa	R_2Cd	2,940,962
$TiCl_4/TiI_4$	$EtAlCl_2$	Et_3Al	2,938,019
$TiCl_4$	Al	MoO_3	2,938,018
$TiCl_4$	$AlEt_3$	$Si_2H_2O_3$	2,938,000
Ti $(OR)_4$	Et_2AlCl	.....	2,936,302
$CaTiF_6$	$R_2AlX/RAlX_2$	.....	2,935,500
V_2O_5	Al	$AlCl_3$	2,935,498
MoS_2	R_3Al	.....	2,935,497
$TiCl_4$	$AlEtCl_2$	$InCl_3$	2,935,496
$TiCl_3$	Hexaphenylethane	.....	2,933,483
V $(OR)_3$	R_3Al	.....	2,933,482
Ti $(OR)_4$	$SbCl_5$	Na	2,930,785
Bauxite	O_2	.....	2,928,814
$TiCl_4$	Al	NaF	2,925,410
$TiCl_4$	R_3GeH	.....	2,925,409
Fe	O_2	.....	2,925,408
$TiCl_4$	Na	Al $(CN)_3$	2,921,056
$TiCl_4$	AlR_3	$SiCl_4$	2,920,062
$TiCl_4$	C	.....	2,919,266
$IrCl_4$	Et_2AlCl	.....	2,918,459
$TiCl_3$	Et_3Al	A hydrocarbon contg. an acidic H atom	2,914,515
ZrH_4	HCl	.....	2,913,442
$TiCl_4$	Al	R_4NX	2,912,424
TiO_2/SiO_2	R_3Al	.....	2,912,421
$TiCl_3$	$R_2Al_2Cl_3$	KCl	2,909,511
$TiCl_3$	R_2AlCl	NaCl	2,909,510
$TiCl_4$	Li	.....	2,908,670
MoO_3	Al_2O_3	RNa	2,908,669
$TiCl_4$	RAl (OR) X	.....	2,905,661
TiAl (alloy)	RX	.....	2,905,646
$TiCl_4$	In presence of ionizing radiation	.....	2,903,404
$TiCl_3$	$AlEt_3$	Ultrasonic vibr.	2,899,414
$TiCl_4$	Al and $AlCl_3$	NaF	2,899,413
$TiCl_4$	R_2Al (OR)	.....	2,898,328
$TiCl_3$	$AlEt_3$	.....	2,893,984
Cu, Ag, Hg Acetylide	.....	.....	2,890,212
MoO_3	Al_2O_3	RNa	2,887,471
$FeCl_3$	R_2AlCl	.....	2,882,263
$TiCl_4$	Na	.....	2,881,156
$TiCl_4$	Et_3Al	.....	2,874,153
Ti $(OR)_4$	$RAlX_2$	.....	2,833,755
Ti $(OR)_4$	$R_2Al_2X_3$	.....	2,824,090
$TiCl_4$	$R_2SnOSnR_2$	.....	2,820,778
$CrCl_3$	R_3Al	.....	Gillespie and Fordham [13]

Solid oxide catalysts, such as the well-known Phillips and Indiana catalysts[27] have been proposed for polypropylene manufacture but the degree of stereospecificity appears to be of a lesser magnitude than that of polymers produced by Natta-type catalysts. This article will, in general, be confined to the use of Natta-type catalysts as a consequence. Certain promoters appear to give truly isotactic polymer from the Indiana-type catalysts, however, and these will be discussed in the paragraphs to follow.

Noteworthy among the compositions other than the "usual" $TiCl_3$-AlR_3 combinations is the molybdena-alumina composition promoted by alkali alkyls. The basic molybdena-alumina composition promoted by active metals, their hydrides, aluminum hydrides or borohydrides has been widely described for ethylene polymerization in patents by Standard Oil Company (Indiana). Such catalysts are not particularly effective for propylene polymerization and are indeed so inert to higher olefins that the latter may be used as reaction solvents in ethylene polymerization with these catalysts. In contrast, when the same oxide mixture is promoted with an alkali metal alkyl, these catalysts will polymerize olefins as high as C_{10}; such composition are the subject of United States patents by the Eastman organization. A molybdena-alumina catalyst promoted with an aluminum alkyl has also been described in a patent by Standard Oil Company (Indiana) as effective in producing an extremely high molecular weight solid polymer from propylene. Yields of 80-90 percent of a propylene polymer which is insoluble in aromatic hydrocarbons have been obtained according to Harban et al.[15]

In contrast to modified molybdena catalysts for which some fair degree of success in propylene polymerization is claimed, the product from the Phillips catalyst has been stated to be a tacky semisolid. The patent literature on the Phillips process discloses a number of operating conditions pertinent to polypropylene manufacture, however, and they are reviewed briefly here. From 10-25 mole percent of propylene is fed, along with 75-85 percent of isopentane and 5-15 percent propane in a typical example. In some cases, 25 percent propylene and 75 percent propane were the only materials fed. Operating temperatures preferred for polypropylene manufacture using the chromia-alumina Phillips catalyst are about 175°-200° F as compared to perhaps 275°-300° F when polymerizing ethylene.

PROCESSING PROBLEMS

One of the problems encountered in polypropylene manufacture involves adhesion of polymer to the walls of the reactor as well as to the blades and shaft of the agitator within the reactor. Since heat removal and temperature control are required, heat transfer coils or the walls of heat transfer jackets are also affected. This phenomenon has been called "bagging" and the polymer which adheres to the inner surfaces of the vessel called the "bag." It is obvious that bagging cannot be tolerated in commercial operation for a variety of reasons.

- Limitation of production capacity due to time-consuming removal of such deposits
- Hindrance or prevention of continuous operation through bagging in the transfer lines
- Interference with agitation and heat transfer with resultant inability to control reaction to produce polymer of optimum properties.

This phenomenon has been found to be of much

greater severity in the case of polypropylene than with polyethylene, polystyrene, etc.

Bagging can be avoided according to one patent (U.S. 2,961,434) by keeping the reactor saturated with propylene from the beginning of the polymerization cycle and by holding the differential between heat through jacket temperature and reaction mixture to 10° C or less.

Whereas the above procedure tries to prevent bag formation, bag removal once formed can be accomplished, according to another patent (U.S. 2,908,761) by heating the reactor wall to 200° to 400° F for 5-10 minutes. The loosening of deposits can be further aided by a simultaneous reduction in reactor pressure just after the heat treatment.

After polymer buildup has occurred and when a shutdown for cleanout is necessary, solid polypropylene can be removed from the apparatus by heating to 338° to 464° F in contact with air until the polymer has a combined oxygen content of, say, 2 percent. The oxidized deposit is then washed out using a solvent boiling above 200° F, such as tetrahydronaphthalene or ethylene glycol.

CONTROL OF POLYMER PROPERTIES

The proof of the polymer is in its properties. The combination of the usual chemical reaction control variables (temperature, pressure, and reaction time) with control of the composition of the complex catalyst give a unique opportunity for precise control of polypropylene properties. Table 5 summarizes the effects of some of these reaction variables on molecular weight.

TABLE 5—Effects of Reaction Variables on Molecular Weight

Variable	Change In Molecular Weight With Increase In Variable	
	Natta Catalyst	Bier Catalyst
Time	Constant	Increases
Temperature	Decreases slightly	Decreases greatly
Monomer concn.	Increases at low conc.	Increases*
Catalyst conc.	Decreases†	Constant*

* At constant reaction time.
† Refers to $TiCl_3$ concentration.

Figure 3 is a "map" showing the location of commercial polypropylene resins and a few of the means of changing directions on that map. One such means involves using hydrogen which has an effect on propylene polymerization ten times as great as that on ethylene polymerization; great reductions in molecular weight can be achieved by controlled addition of hydrogen in polypropylene manufacture. Other agents which may be used for molecular weight control, as noted by Natta[22] include organometallics, alkyl halides, hydrogen chloride, and active hydrogen compounds. Molecular weight varies as the square root of AlR_3 or H_2 concentration.[21]

Stereospecificity is reduced by various factors[22] including

- An increase in the ionic radius of the Group I-III metal as is shown in Table 6
- An increase in the chain length beyond 2 carbon atoms of the alkyl groups bonded to the Group I-III metal
- By an increase in temperature.

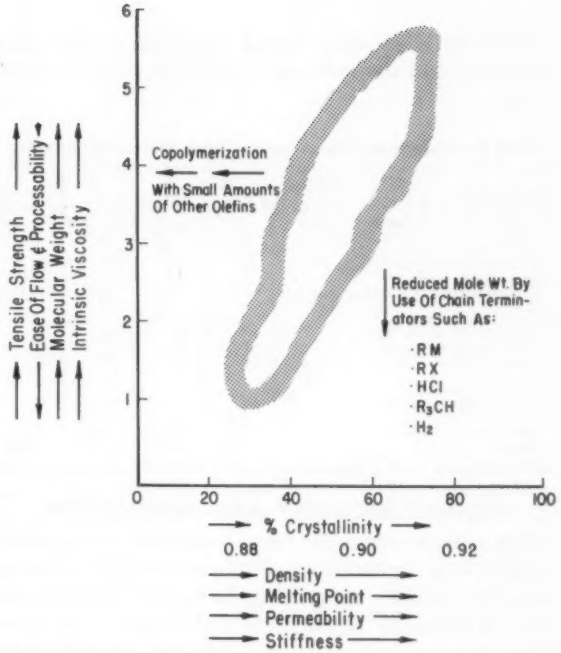

FIGURE 3—"Map" showing the location of commercial polypropylene resins and a few of the means of changing directions on that map. The plot shows flow property of polypropylene (which defines processability) versus mechanical property (which defines utility) according to Goppel.

TABLE 6—Effects of Secondary Catalyst Component (20)

Metal In Alkyl	Ionic Radius Of Metal	Pecent Polymer Product Insol. Boiling Heptane
Be	0.35	94—97
Al	0.51	80—90
Mg	0.66	78—85
Zn	0.74	30—40

Above data obtained using violet $TiCl_3$ at 75°C and a propylene pressure of 2.4 atm.

Any one of these factors tends to make the catalyst complex more desorbable and dissociable. Interestingly, when a titanium halide-beryllium halide-aluminum halide catalyst is used, the beryllium governs in stereospecific effect, even though that smaller atom may be present in minor amount.[21]

Table 7 shows some of the effects[19] of variation in the primary or transition metal catalyst component on polymer properties.

TABLE 7—Effect of Primary Catalyst Component

Original Form of Transition Metal	Principal Type of Stereoisomer Present in the Polymer Product
Valence less than maximum, in a form insoluble in hydrocarbons: $TiCl_2$, $TiCl_3$, VCl_3, etc.	Isotactic
Composed of highest valence, soluble in hydrocarbons: $TiCl_4$, VCl_4, etc.	Mixed atactic and isotactic
In oxygenated form: $TiCl(OR)_3$ $Ti(OR)_4$ on an amorphous support	Atactic

Table 8 shows some typical variations in operating procedure and the resultant changes in polymer properties.

TABLE 8—Propylene Polymerization With Violet $TiCl_3$ Catalyst

Run Number	1	2	3	4
Polymerization Conditions				
Cat. conc., percent on diluent	0.12	0.23	0.18	0.19
Al/Ti mole ratio	2.0	1.2	2.1	2.1
Reaction temperature, °C.	65	69	67	68
Run length, hours	9	8	19	21
Normal reactor residence, hours	0.9	0.9	0.84	0.85
Polymerization Results				
Catalyst efficiency, W/W	10	20	40	44
Reaction rate W/hr/W	11	23	47	52
Conversion, percent	12	48	77	85
Polymer Properties				
Heptane insol., percent	58	37	63	60
Intrinsic visc., dl/g	2.87	.....	1.72	1.67
Melt index, g/10 min	0.1	0.57	1.61	2.60
Density, g/cc	0.882	0.884	0.890	0.885

PRODUCT RECOVERY AND PURIFICATION

Once the reaction has been completed, the residual catalyst must be "killed" and then the remaining metal ions removed from the polymer by one of various physical and chemical treatments. Table 9 shows the correlation between the color of a molded polypropylene product and the titanium content; it can be seen immediately that efficient catalyst removal is necessary to produce an attractive and competitive product with good color (and good electrical properties).

TABLE 9—Correlation Between Color of Molded Polypropylene and Titanium Content

Polymer Color	Ash Content, p.p.m. Ti
Colorless (or white)	0—60
Pale yellow	60—100
Yellow	100—160
Amber	160—200
Dark amber	200

Table 10 summarizes some of the many treatments that have been patented for such deashing operations.

Prior to deashing, an effective quenching step is helpful in minimizing the metal content of the polymer. Carbon tetrachloride is particularly desirable as a quenching agent; C_1 to C_4 alkyl hypochlorites are also useful for this purpose.

About the Author

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TABLE 10—Techniques Proposed for Deashing Polypropylene

Treating Agent	U.S. Patent Reference
Wash with C_1 to C_3 alcohol in inert atmosphere	2,962,488,
Polymer is foamed, chilled, comminuted then washed with nitric acid	2,957,859
Wash with glycol, glycerol, sorbitol, or cyclohexanol in an aqueous alcoholic solution	2,956,983
Wash with alpha diketones	2,955,107
Wash with mixture of diacetone alcohol and a lower alcohol	2,955,106
Wash with aqueous alkaline bicarbonate solution	2,951,833
Filtration of polymer solution through asbestos	2,935,499
Wash with ethylene glycol	2,928,815
Heating with isobutylene to recover Al-isobutyl	2,927,103
Wash with aqueous oxalic acid	2,912,420
Treatment with de-gassed water	2,905,659
Treating molten polymer with aqueous alcohol	2,886,561
Grinding polymer in ball mill with $TiCl_4$ to give Ti-free polymer plus $TiCl_3$	2,880,199

Even the choice of catalyst may be made with an eye to polymer purification. Thus, a mixture of a vanadic ester and an aluminum alkyl or hydride may be used to provide a halogen-free polypropylene catalyst which contains no acid materials to corrode molding and extrusion equipment if not completely removed from the polymer.

POLYMER FINISHING

Shock cooling can be employed to lower the brittle point of crystalline polypropylene. The polymer is heated above its melting point in a solvent and then cooled to a temperature below 70° C in 10 minutes or less. The resultant product has an appreciably lowered brittle point (reduced, say, from 50° F to 15° F).

Polypropylene is stated to be inherently less stable than polyethylene and consequently a variety of inhibitors are being developed to act as antioxidants and light stabilizers. Also problems of dyeing polypropylene are the subject of intensive investigation.[9]

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(Note: This bibliography has been confined to references to the periodical literature in the interests of brevity and simplicity. Further information on patents cited in the text by number only can be obtained by the interested reader by way of the Patent Office Gazette.)

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Why Polypropylene Uses Will Grow

Because of its low density, high strength and exceptional versatility, this newest olefin polymer has a bright future

James M. Jordan and Jack L. Craig*
Spencer Chemical Company, Kansas City, Mo.

Polypropylene, because of its low density, high strength and exceptional versatility, is expected to reach a production capacity of 400 million pounds by 1963 and 500 million pounds or slightly more by 1965.

Since its introduction to the U.S. market as a commercial product in 1957, this olefin polymer has become one of the most talked about products on the plastic scene. Current production capacity is estimated at 105 million pounds.

Polypropylene was introduced at a price of 65 cents per pound in the natural color. The price has been reduced three times since its introduction to the present level of 42 cents per pound for the general purpose, natural colored resin.

Before forecasting polypropylene consumption let's look at the development of the markets for the other polyolefins, conventional and linear polyethylene. Conventional polyethylene was first produced in the United States in 1943. It was 1952 before consumption reached 100 million pounds. This growth would have undoubtedly been faster had it not been for the World War II marketing limitations and the patent situation, but even under ideal conditions, about five years would have been needed to reach the 100 million-pounds level.

Linear polyethylene was available from semi-commercial sized plants during 1956 and reached approximately 100 million pounds of consumption during 1959. Linear polyethylene, with all of its early problems, has shown the fastest growth of any plastic in history, and yet four to five years was needed to reach the 100 million pound rate of annual consumption.

It is unlikely that polypropylene can expect much more rapid growth than these other plastics have shown during their development periods. While polypropylene has certain advantages compared to other thermoplastics it also has disadvantages and problems which must be resolved. As is the case with any new plastics, time is needed to develop good compounds for all major end-uses. Processors tend to move slowly in accepting a new material until they can build a "use history" and prove the plastic's value.

With these thoughts in mind, Table 1 shows market forecasts for polypropylene from 1960 through 1965. Major usage areas are discussed in some detail to show the reasoning behind the market forecast.

TABLE 1—Market Estimates for Polypropylene Consumption
(Millions of Pounds)

Use	1960	1963	1965
Film and Sheet	2	45	80
Injection molding	17	50	80
Wire and Cable	*	5	15
Coatings	*	5	15
Blow molding	*	10	20
Pipe, Tubing and Shapes	1	5	10
Miscellaneous (includes monofilaments and fiber)	10	35	60
Total U.S. Domestic Consumption	30	155	280
Export Sales	—	5	10
Total Sales	30	160	290

*Development quantities.

Total film production in 1960 approximated 1 billion pounds, of which about 75 percent was used for packaging as shown in Table 2.

TABLE 2—The 1960 Film Market
(Millions of Pounds)

	Total for All Uses	Used in Packaging
Cellophane	450	430
Polyethylene	355	260
Vinyls	100	15
Vinylidene Chloride	35	30
Cellulose acetate and cellulose acetate butyrate	20	7
Rubber Hydrochloride	20	20
Polyester	22	7
Polystyrene	5	4
	1,007	773

Polypropylene Film

The appearance (excellent gloss and clarity), physical properties and probable eventual cost of polypropylene

* Present address: Texaco Inc., New York City.

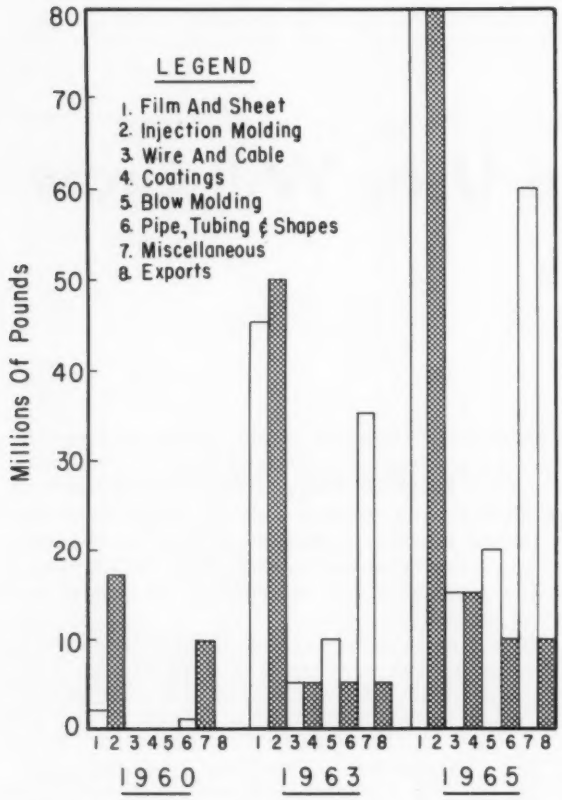

FIGURE 1—Here's how the consumption pattern for polypropylene should break down for the next five years.

film indicate that the greatest portion of its potential market should be found in the field of packaging.

The composition of the packaging film market (see Table 2) shows that more than 90 percent of the potential competition facing polypropylene film is cellophane and polyethylene. All of the other film materials shown might be regarded, more or less, as "specialty" films which are relatively high in cost and are usually used only when they satisfy some particular need. Polypropylene film might, by chance, capture a small part of the markets held by specialty films. The unique properties of these specialty films have enabled them in most cases, though, to hold onto their markets in the face of competition from polyethylene film, and it seems unlikely that polypropylene film is sufficiently different from polyethylene film to force their displacement on a substantially larger scale.

Polypropylene film then appears most suitable for applications which might otherwise be satisfied by cellophane or polyethylene. More specifically, its gloss, clarity and strength properties would seem to make it a contender for part of the cellophane market. About 70 percent of all cellophane used is consumed in overwrapping applications, with most of the remainder being used in bag form, with very little overwrapping or direct wrapping. The relatively low tear strength of polypropylene film and its low burst strength in bag form makes it more nearly comparable to cellophane in these properties than to polyethylene film.

Automatic Machine Wrapping Applications. Today only a relatively small portion of polyethylene film is used in automatic machine wrapping operations, all at lower wrapping speeds. From what has been seen to date polypropylene film might be substituted in most of the machine wrapping applications now held by polyethylene film.

Baked Goods. This year the packaging of baked goods should consume approximately 150 million pounds of transparent films, including about 140 million pounds of cellophane and 10 million pounds of polyethylene. As is now becoming evident, the bakery goods field should be one of the easier markets for thermoplastic films to invade. With a considerable amount of development work, polypropylene film should be able to build itself a good potential as a packaging material for baked goods.

Textile Goods. Polyethylene film is currently being consumed at a rate of about 25 million pounds yearly in the packaging of soft goods. Cellophane and vinyl film share most of the remainder of this market, but their combined volume is only about half that of polyethylene. On the basis, primarily, of its excellent clarity and its glossy and "crisp" appearance, polypropylene film should be able to capture some of the textile packaging uses held by each of the three films mentioned.

Paper Products. Although the current rate of consumption of polyethylene film in the wrapping of paper products is in the range of only 6 to 7 million pounds per year, it is advancing rapidly in the replacement of cellophane and paper wraps. Polypropylene film would appear to be almost on a par with polyethylene in its chances for future growth in this market.

Frozen Foods. Polypropylene film probably has relatively little potential usage in this field unless it should find some applications as a carton overwrap material replacing cellophane.

With a great deal of development effort these problems might be worked out, but there is the possibility that in the intervening time the tobacco industry might develop a completely new type of package (e.g., an all-plastic or plastic-foil package) which would virtually do away with this overwrap market.

Bag Packaging and Miscellaneous Wrapping. As mentioned previously, most of the polyethylene film consumed in packaging today is utilized in bag form. The packaging of fresh produce will consume an estimated 85 million pounds this year. Unless the balance of properties of polypropylene film is significantly improved, it is not likely to make any substantial penetration into this type of market. Bags by dry cleaners and laundries consumed approximately 30 million pounds of polyethylene film last year. Unless poly-

propylene film could be produced so as to have the relative balance of properties as exhibited by blown polyethylene film, it probably would have little chance of competing in this market.

It is impossible to discuss each potential field of application for polypropylene film and compare its relative merits with polyethylene, cellophane and other packaging materials. The following observations should cover most of the potential packaging applications for polypropylene film: It appears that much of the packaging market which will be developed for polypropylene film is of the type now held by cellophane: that is, in the overwrapping of cartons, trays, or boxes and the direct wrapping of individual items. This conclusion is based primarily on the clarity and gloss, the strength properties and the potential cost advantage of polypropylene film as compared to cellophane. Unfortunately, for the short-term market, these are the types of packaging applications which require large amounts of development effort—in wrapping machine design and operation and in the adaption of the film to the machine and to the product to be packaged.

Polypropylene film also has the advantages of better moisture resistance and longer shelf life as compared to cellophane. Cellophane, though, has the very important advantage of good machinability (and a vast number of installations of machines designed for its handling) and a tremendous backlog of experience which has gone into modifying cellophane to obtain the properties desired for specific packaging applications.

Polypropylene film, as it exists today, appears to be a less likely contender for bag-type packaging applications, which are represented principally by polyethylene film today. The good clarity and gloss of polypropylene film would be advantages in bag packaging, but the poor strength characteristics of polypropylene (as defined in terms of impact, tear, or burst strength and puncture resistance) is a very serious deterrent to such uses.

POLYPROPYLENE SHEET

The present market for thermoplastic sheet materials is approximately 250 million pounds, of which about 80 percent is used for thermoforming applications. The remaining sheet is consumed in various fabricated products, made by such methods as punching, welding and cutting.

The polyolefins are a minor factor in the sheet market today. Conventional polyethylene has had limited use, while linear polyethylene has made somewhat better progress, but is still quite limited in applications. Polypropylene sheet appears to offer the greatest opportunity for polyolefin sheet materials; however, most of the basic problems that have limited polyolefin sheet usage in the past are still present, but in most cases to a lesser extent.

Figure 2 shows estimates for the consumption of film through 1965. The rate of growth of polypropylene film shown is a relatively rapid pace of development for a new film material. These estimates are based on substantial progress being made in the handling of polypropylene film on wrapping machines, on continued proof of the reportedly good processability of polypropylene film by the commercial extruder and on the achievement of equal packaging costs in comparison with cellophane or polyethylene in at least a few packaging markets of significant size. Thus polypropylene consumption for film and sheet should grow as follows:

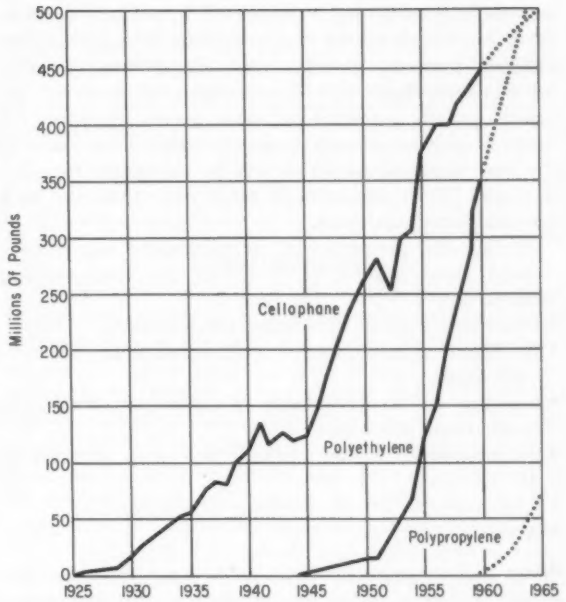

FIGURE 2—From these estimated U.S. consumption curves for cellophane, polyethylene and polypropylene notice the unusual rapid growth prediction for polypropylene.

FILM AND SHEET		
1960	1963	1965
2×10^6	45×10^6	80×10^6

INJECTION MOLDING MARKETS

Injection molding is a major processing method for all thermoplastic materials. During 1960 approximately 845 million pounds of thermoplastic resins were injection molded. Of this market, styrene plastics of all types accounted for almost 60 percent, polyethylene added another 20 percent, and the cellulosics another 10 percent. Thus these three groups of plastics made up 90 percent of the injection molding consumption of resins.

In addition, approximately 325 million pounds of thermosetting resins, primarily phenolics, urea and melamine, were processed by compression molding during 1960. Thus the total market for plastic molding compounds today is well in excess of 1 billion pounds.

It is quite logical to assume that polypropylene will not capture a major portion of the molding market as it exists today, for it has been demonstrated again and again that each new plastic material must carve out its own "niche" in this industry. Polypropylene is displacing small amounts of some of the thermoplastic

and thermosetting resins consumed in existing applications, but much of the future growth of polypropylene molding materials should come about through other means, including: (1) Replacement of some of the future growth potential of other plastic materials because of polypropylene's greater suitability for many of the new applications which will be developed for plastics, and (2) replacement of other basic materials such as metal, wood and glass.

Among the properties of polypropylene which have created great interest in it as an injection molding material are:

- Good performance at elevated temperatures.
- Excellent reproduction of mold detail and good surface finish.
- Rigidity, stiffness, resistance to creep and other good mechanical properties.
- Polypropylene shrinks virtually the same amount in all directions.
- Resistance to stress cracking is outstanding.
- A unique flex life.

Price. Polypropylene, in relation to some other thermoplastic materials, is less expensive on a cents-per-cubic-inch basis than ABS polymers, nylon, urea-formaldehyde and cellulose acetate, butyrate and propionate. These materials are due for some real competition from polypropylene in many molding applications to be developed in the future. In addition, polypropylene will compete with linear polyethylene, impact styrene, copolymer styrenes and other plastics where the final cost of the item or the properties of the finished piece may benefit from the advantages which polypropylene can give.

Automotive Uses. One of the more promising potential markets for polypropylene may be found in the automotive industry. This industry is using larger amounts of plastics each year. As late as 1956, the "average" or "composite" car was utilizing only 11 pounds of plastic materials. The 1961 models use an average of about 22 pounds per car, and by 1963 it is estimated that approximately 35 pounds of plastics will be used in the average car.

Polypropylene injection molded parts appear in a few of the 1961 models, in items such as clips, knobs, grilles, nozzles, and plugs. Total usage of polypropylene in the 1961 cars is quite small; but the 1962 and 1963 models should provide some substantial increases in the number of applications and the poundage consumed.

Other areas of potential usage for parts made from polypropylene include such items as blow molded sun visors, molded accelerator pedals and instrument panel housings.

Appliance Parts. Appliances, large and small, offer a fruitful field for plastics marketers. As evidence of this, approximately 200 million pounds of plastics were consumed by appliance manufacturers in 1960.

Polypropylene has fared exceptionally well in its introduction to the appliance industry. Virtually every appliance manufacturer utilizes one or more polypropylene components or parts in current product lines. Polypropylene molded parts have gained particular interest in appliances which operate under conditions involving relatively high temperatures. Stress cracking resistance has also been of value in appliance applications.

Housewares constitute another major market for plastic materials. Molded houseware items accounted for approximately 20 percent of total thermoplastic molding resin consumption last year. In the order of 10 percent of the styrene molding resins and 65 to 70 percent of the polyethylene molding resins were molded into houseware items.

The degree of success polypropylene achieves will depend upon:

1. The price of polypropylene vs. the price of polyethylene (both conventional and linear) and styrene.

2. The success in promoting before the consumer the advantages of polypropylene—including higher heat resistance, freedom from stress cracking, good rigidity with good resilience, flex resistance and abrasion resistance.

Closures. The present plastic closures market is dominated by thermosetting resins, primarily urea and phenolics. Thermoplastic closures are now predominantly styrene or polyethylene. The total amount of plastic closures consumed at the present time represents an annual market in excess of 30 million pounds of resin usage.

Polypropylene is quite promising as a closure material. It offers all of the previously stated advantages of a thermoplastic and in addition: Gives superior threads as compared to polyethylene; offers stress crack freedom; and does not generally need a cap liner as do the styrene, urea or phenolic closures.

Plastic Pipe Fittings. Pipe fittings constitute another market for injection molded thermoplastics, though a relatively minor one. The annual consumption of thermoplastics in this field amounts to only about 2 million pounds. Styrene, ABS polymers, vinyls and nylon are the principal materials used today.

Polypropylene began to invade this market shortly after the commercial introduction of the resin in the United States. Today several different firms offer polypropylene fittings, valves and similar items.

Polypropylene appears to be an ideal material for fittings for polyolefin pipe. It offers good temperature resistance, freedom from stress cracking, rigidity and attractive appearance. Polypropylene fittings approach impact styrene fittings in cost and are less expensive than nylon fittings.

Polypropylene should win close to one-half the market for plastic pipe fittings within the next two to three years.

Through the next five years, polypropylene for injection molding should grow as follows:

INJECTION MOLDING

1960	1963	1965
17×10^6	50×10^6	80×10^6

Development quantities only

WIRE AND CABLE COATING

The total annual consumption of wire and cable coating materials in the United States is today approaching the impressive figure of one-half billion pounds. In a relatively small number of years, plastics have succeeeded in capturing almost half of this market, with the other half of the market continuing to be represented by old, well established materials such as rubber, paper, cotton, jute, metals, varnishes and lacquers. Today plastics continue to deepen their penetration into the wire and cable industry, not only by their displacement of older materials, but also by offering a unique combination of properties which allows the manufacture of coated wire and cable products of new design for many special purposes.

With only a very limited amount of development work on polypropylene having been conducted by the wire and cable industry as of this time, it would appear that polypropylene offers the following possible advantages as compared to polyethylene in this area of usage:

1. Higher permissible operating temperatures
2. Freedom from environmental stress cracking
3. Improved abrasion resistance

Taking into consideration the various potentialities for polypropylene as a wire and cable coating material, as well as its drawbacks, we forecast the consumption of polypropylene by the wire and cable industry will follow the pattern shown below over the next five years:

WIRE AND CABLE

1960	1963	1965
*	5×10^6	15×10^6

*Development quantities only

EXTRUSION COATED AND LAMINATED MATERIALS

The realm of coated and laminated products embraces an almost infinite number of possible combinations of materials. In addition to the many types of papers which may be included in the structure of a packaging material, the converter of coated or laminated products also may use foil, cellophane, one or more of the many plastic films available, or textile fabrics.

Among the plastic films used, polyethylene is the unquestioned leader with an estimated 75 million pounds being consumed in 1960 in all types of coatings, mainly for packaging materials.

Polypropylene will undoubtedly find a few uses in this industry on the basis of its own unique set of properties most nearly satisfying the requirements of some specialized applications. It is apparent, though, that if polypropylene is to achieve any large volume usage in the extrusion coating industry it must compete on an equal-performance, equal-cost basis with polyethylene.

As the situation exists today, it would appear that polypropylene is meeting many of the same problems which beset linear polyethylene in its introduction to the extrusion coating industry.

The processing problems which must be overcome if polypropylene is to become a competitive extrusion coating material, plus the near term disadvantage of a relatively high price differential on polypropylene as compared to polyethylene, lead us to forecast a relatively slow growth for polypropylene usage in the production of coated and laminated materials as shown below:

COATINGS

1960	1963	1965
*	5×10^6	15×10^6

*Development quantities only

BLOW MOLDING

Attempts to replace glass bottles with plastic containers date back almost to the beginning of the plastics industry. It was not until the free availability of polyethylene for peace time uses after World War II that the plastic bottle became a commercial reality. When the first successful polyethylene bottle appeared on the market in 1947 it was hailed as a major packaging development with a brilliant future and the first few years of its spectacular growth seemed to confirm this. As the early growth years passed, though, the polyethylene bottle market hit snags which flattened its growth curve almost to a plateau, as a result of obstacles such as the Korean War—induced shortage of polyethylene, misapplications, the disadvantage of a relatively high cost and a production situation closely hemmed in by patents, secrecy, and a general nonavailability of blow molding equipment on the open market.

For these reasons growth in the polyethylene blow molding industry was relatively slow in the early and mid '50s. Then approximately three years ago, some very significant changes began to be seen. Blow molding equipment of several different designs became available to anyone wishing to enter the market; also new and improved materials became available such as medium density polyethylenes, linear polyethylene and copolymers. Not of least importance is the fact that the price of resins declined significantly during this period. Thus, in the last few years we have seen revolutionary changes in the blow molding industry. Whereas just three to four years ago there were only perhaps 20 firms performing commercial blow molding, there are today in excess of 200 blow molding companies. The result has been a phenomenal growth in the use of polyethylene in blow molding from an estimated 9 million pounds in 1955 to 40 million pounds in 1959 and 75 million pounds in 1960.

Much of the new growth in this market has been attributable to the upsurge in the use of linear polyethylene and copolymer materials in semi-rigid utilitarian containers for liquid household products, most notably liquid detergents.

Primarily because of the low temperature deficiency of polypropylene, but due also to its relatively higher price compared to other polyolefins, we forecast a relatively slow development of markets for polypropylene in blow molded containers and other items as shown below:

BLOW MOLDED

1960	1963	1965
*	10×10^6	20×10^6

*Development quantities only

PIPE, TUBING AND EXTRUDED SHAPES

Polypropylene pipe, at this early stage in its development, is an inconsequential factor in the $65-million plastic pipe industry. Small amounts of polypropylene pipe have been extruded primarily for evaluation purposes. A handful of extrusion firms claim to offer polypropylene pipe or tubing, but as far as is known none of these companies include polypropylene in their standard product lines.

Polypropylene pipe is expected to compete primarily against the rigid and semi-rigid thermoplastic pipe materials, including ABS polymers, rigid vinyls, and linear polyethylenes. It might also present conventional polyethylene with some competition in smaller diameter pipe if it should prove to be coilable.

As of this time, polypropylene would appear to present the following advantages and disadvantages when considered as an entry into the plastic pipe market:

Advantages: Lowest weight—more footage per pound; high operating temperatures; stress crack resistance; higher strength than the polyethylenes, but not higher than the other rigid materials, and excellent chemical resistance.

Disadvantages: Low temperature brittleness—has shown brittleness tendencies at temperatures as high as 40° to 50° F; low impact strength; not solvent weldable for fittings; lack of coilability, and relatively high price today in comparison to polyethylene.

Lumping together the potential markets for polypropylene pipe, tubing, and extruded shapes, and attempting at the same time to give due consideration to each of the performance advantages and handicaps of the polymer, we would forecast a total consumption of polypropylene in this area of usage as follows:

PIPE, TUBING AND SHAPES		
1960	1963	1965
1×10^6	5×10^6	10×10^6

MONOFILAMENT AND FIBER

Monofilament usage is a small portion of the synthetic textile industry. Materials which have won prominence as textile fibers have been produced from melt solutions through spinnerette heads in the form of staple or tow. Monofilaments are not as easy or as versatile to work with in true textile applications.

The present market for plastic monofilaments is estimated to be about 45 million pounds, divided approximately as shown in Table 3.

TABLE 3—1960 Monofilament Market
(Millions of Pounds)

Material	Consumption	Major Uses
Saran	25	Furniture webbing, auto seat covers, screening.
Nylon	6	Brush bristles, fish lines.
Polyolefins		Rope, furniture webbing, industrial fabrics, specialty textiles, fabrics.
Linear and conventional polyethylene	3	
Polypropylene	8	
Styrene and other	3	Broom and brush bristles.
Total	45	

Polypropylene appears to have a bright future in the monofilament field, as well as offering the first real hope of a polyolefin textile fiber.

Textile Fibers. The real poundage increase in fiber consumption is acruing almost completely to the group of new synthetic fibers of which the principal members are: nylons, acrylics, polyesters and the glass fibers. Although the growth potential of synthetic fibers is attractive, the field is not an easy one for new entries.

The combination of potential low price and properties adequate for a wide range of applications has created interest in polypropylene fibers among textile manufacturers both here and abroad. Polypropylene fibers are light in weight so that a little goes a long way. The fibers are strong, have a good resistance to mechanical abuse, such as flexing and abrasion and are dimensionally stable. They have good low temperature properties and excellent chemical resistance.

The market estimates below include both monofilament and true textile fiber consumption and for the years 1960 and 1963 are predominately monofilament applications. ##

MONOFILAMENT AND TEXTILE FIBER		
1960	1963	1965
8×10^6	25×10^6	45×10^6

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Keep Equipment Cost Data Current

Using the method described here and the data sheets which will follow in this series, you can build your own process equipment estimating file

N. H. Prater, Mobay Chemical Co., Pittsburgh
John Mylo, The Chemstrand Corp., Decatur, Ala.

PROCESS EQUIPMENT COSTS serve as the basic building block for preparing capital cost estimates in the hydrocarbon processing industry and, therefore, are of prime importance to the estimator. Volumes have been written and virtually thousands of charts prepared covering the cost of various types of process equipment. Many of the methods employed and charts presented are so general that only limited reliance can be placed on the data. Since the cost of process equipment is so vital in the preparation of realistic capital cost estimates, a method for compiling current, yet accurate, cost data covering the basic types of equipment normally encountered should be developed.

EQUIPMENT COST DATA FILE

The approach used in this series gives the basic descriptive information required along with equipment costs in graphic form for a particular item of processing equipment. Each basic cost sheet covers a broad operating range for one type of equipment in conjunction with its cost and general specifications. These data sheets then serve as a "do it yourself kit" for compiling a comprehensive estimating data book to fulfill your individual needs.

The first step in preparing these data sheets was to determine the general capacity, size of range of service for each different type of equipment of interest. In most instances the complete cost of the equipment item, accessories, etc., will increase uniformly, with size for a given item of equipment from a given manufacturer.

Having selected the area of interest, the next step was to select and obtain price information from the equipment manufacturer for various size and capacity combinations to cover the desired service range. With this price information in hand, a full range price curve for the particular equipment item was prepared. Where possible, price data for a particular type of process equipment was obtained from a single manufacturer. Equipment purchased from other manufacturers may have prices differing from those used to plot the curves. In most instances, however, the customer's specification for a particular equipment type will sufficiently define the piece of equipment so that no large price differential will be found among customary suppliers.

UP DATE EQUIPMENT PRICES

Equipment prices used in the preparation of the charts will change from time to time due to revised specifications or to a general increase in manufacturing costs thereby necessitating periodic corrections to reflect current prices. The desired method is to incorporate the manufacturers actual price changes in the form of correction factors as they become available. However, where no change in specifications have been made, a periodic general price index correction will often be satisfactory. This procedure points out the benefit of using price data from a single manufacturer since his price corrections will, in most instances, be uniform for all

Equipment Cost Data File

Beginning next month, PETROLEUM REFINER **brings you a series on process equipment costs. Actual vendor quotations for all types of process equipment will be used. These data are plotted so that costs for a wide range of size and capacity for each type of equipment can be quickly determined. Making the Equipment Cost Data File even more useful is the complete descriptive information required to define the equipment.**

These cost data can be kept up to date by applying reliable cost index corrections or by securing current quotations from vendors. Cost corrections can be plotted on the graphs, wtih appropriate dates, and your Equipment Cost Data File will reflect today's prices.

You will find these cost data to be extremely useful when making evaluation estimates for proposed plant expansions. You can start building your estimating handbook by clipping the Equipment Cost Data File in PETROLEUM REFINER.

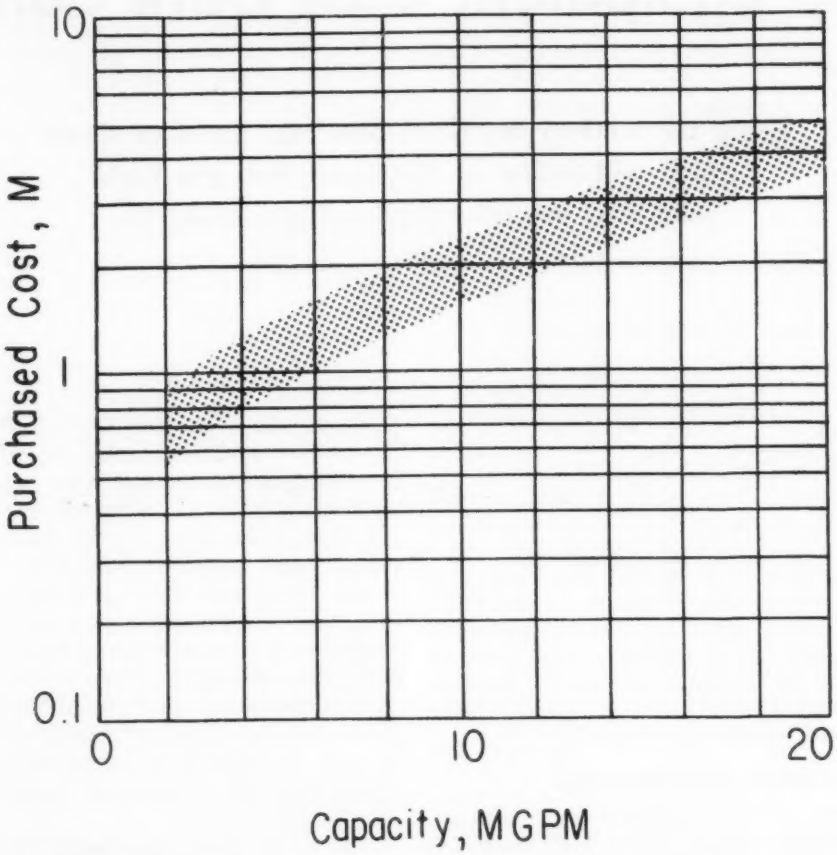

FIGURE 1—When using these generalized cost data for horizontal centrifugal pumps in Type 304 SS (without driver), keep in mind that they are for standard conditions when pumping water. You must apply corrections for different fluids and pump accessories to comply with individual specifications.

size and capacity ranges for each individual type of equipment.

HAZARDS OF GENERALIZED COST DATA

An example will show possible errors when using generalized cost charts or table. This type of price information usually gives a range of prices for a particular service thereby making it virtually impossible to allow for individual preference, type, materials and actual service requirements. A generalized price curve for horizontal centrifugal pumps is shown in Figure 1. Suppose the cost of a horizontal centrifugal pump constructed of Type 304 SS to transport 2,000 gpm of oil having a viscosity of 500 centipoise and a specific gravity of 1.0 at a pumping temperature of 400° F was to be estimated. The suction pressure will be at atmospheric pressure and the discharge head will be 250 feet of liquid. The motor will be Class I, Group D, Division I classification. From the generalized curve shown in Figure 1, the estimated cost of the pump without driver is $3,500. However, from a vendor's price the following cost was derived for the desired pump service:

Basic Pump Cost	**$4,675**
Addition for Water Cooled Stuffing Box	**170**
Total price	**$4,845**

Here the basic pump required to handle the high viscosity stream would have a corresponding capacity of 2,470 gpm at a head of 310 feet of liquid when handling water. After preparing a process equipment cost "kit," the price for the particular pump required for the service can be obtained from the appropriate cost data sheet.

APPLICATION

The approach presented here is extremely helpful when expansion to existing facilities are contemplated. With charted cost information of this type for the various process equipment items for a range of capacities, data is always available and up to date.

Watch for "Equipment Cost Data File" in future issues. Clip these and build your own estimating data book.

(To be continued)

Analyze Plant Control by Transient Response?

Heat exchanger example shows transient response method is just as good as frequency response for determining controller settings. A simple equation derived for primary control compares favorably with actual response

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TRANSIENT RESPONSE techniques can be used to analyze automatic control loops in the plant, as shown by a simple heat exchange problem. A method using these techniques is also outlined for use in primary control loops. This work brings into sharper focus the scattered information on simple methods for control loop analysis.[1,2,5]

Description of Equipment and Methods. Experimental equipment utilized for acquiring test data is shown in Figure 1. Key items are the exchanger, control valve, temperature pickup and transmitter, and an electronic temperature recorder-controller. The exchanger is a small, general purpose model, four-pass, approximately 2 feet long and 5 inches in diameter. Heavy insulation covers the entire exchanger. Temperature indication is by iron-constantan thermocouple with dial thermometers for checking and calibration. A millivolt signal from the thermocouple is amplified in a thermocouple converter which has an adjustable zero and span setting. The electronic recorder-controller is equipped with proportional, reset, and rate control actions. The control valve is an air-to-close diaphragm type with linear characteristics. An electro-pneumatic converter is mounted atop the control valve. The converter takes a 1-5 ma. signal from the electronic controller and converts it to 3-15 psi diaphragm pressure on the control valve which regulates the flow of 60 psig steam. The controlled variable is temperature of the water effluent from the exchanger.

Since the objective of the work was to provide practicing plant engineers with simplified control loop analysis methods, transient response data were used exclusively for the open loop case. In comparison with frequency response techniques, such data are relatively easily acquired in a minimum of time. The procedure consisted of establishing water flow, steam flow, and water effluent temperature at steady conditions. The feedback control loop was broken at the controller by placing it on manual. The steam valve was suddenly opened a small amount by manipulation of the manual control knob on the recorder-controller. The transient response curve shown as a heavy solid line on Figure 2 resulted. Many transient response curves were run under different operating conditions, but this one has been selected as typical and therefore will be used in calcula-

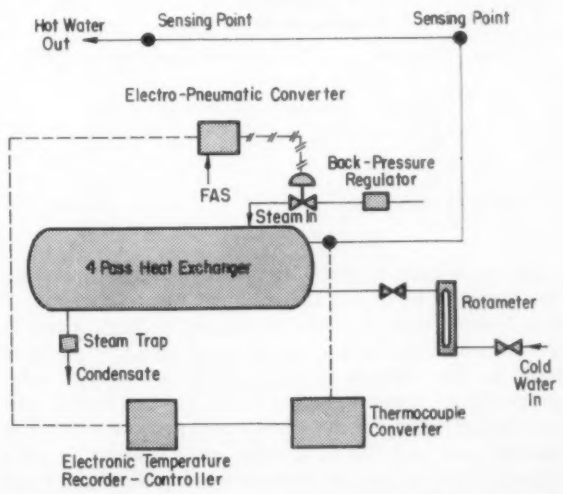


FIGURE 1—Test data was taken from this experimental equipment.

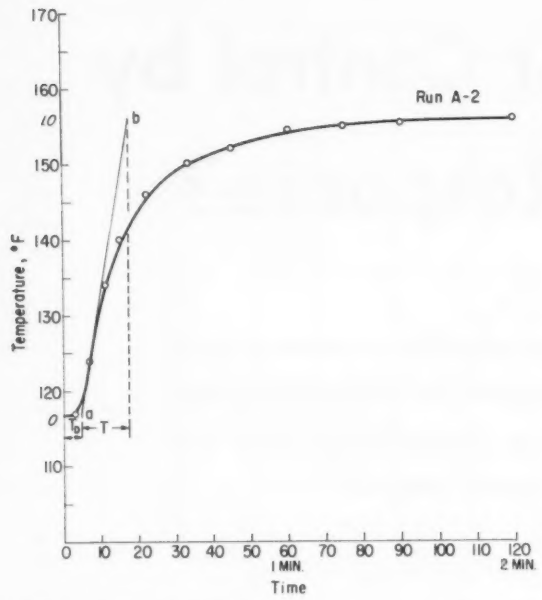


FIGURE 2—This plot of transient response data shows process lag time, T, and dead time T_D.

tions and for comparison purposes. A typical set of transient reponse data is shown in the Tables 1 and 2 together with pertinent steady state conditions:

TABLE 1
Steady State Conditions

	Initial	Final
Steam Flow	1.72 Pounds/ Minute	3.49 Pounds/ Minute
Water Flow	39.2 Pounds/ Minute	39.2 Pounds/ Minute
Water Inlet Temperature	68° F	68° F
Water Effluent Temperature	117° F	156° F

TABLE 2
Transient Response Data

Time (Seconds)	Effluent Temperature (°F)
0	117
3.75	117
7.50	124
15.00	140
22.50	146
33.75	150
45.00	152.5
75.00	155
120.00	156

In the interest of obtaining proper controller settings, the first step is to plot the transient response or "reaction Curve" data as shown in Figure 2. Next, a line is drawn extending the final steady state temperature value back to the ordinate or temperature scale. The total temperature change occurring during the transient is then normalized; that is, the intial temperature level is labeled zero and the final value one. Line ab is then drawn which is tangent to the steepest part of the transient curve. The amount of time between the intersection of the line ab with the initial and final temperature is the process lag time T. Apparent dead time T_D is obtained by measuring the time of initial steam flow disturbance to the lower intersection of tangent ab. As it turned out for this process, T = 0.20 minute and T_D = 0.083 minute. It is also easily seen that the slope S of the reaction curve is 1/T which is 1/0.2 or 5/minute.

Calculation of Controller Settings. The simple formulas recommended by Ziegler and Nichols[3] together with numerical substitutions are as follows:

Two Mode Control (Proportional Plus Reset)

$$K_p = \frac{100}{\text{prop. band}} = \frac{1}{1.1\ ST_D}$$

$$\text{Prop. band} = (100)\ (1.1)\ (S)\ (T_D)$$

$$= (100)\ (1.1)\ (5)\ (0.083) = 46 \text{ percent}$$

$$\text{Reset} = \frac{0.3}{T_D} = \frac{0.3}{0.83} = 3.5 \text{ repeats/minute}$$

Three Mode Control (Proportional Plus Rate Plus Reset)

$$K_p = \frac{100}{\text{prop. band}} = \frac{1}{0.83\ ST_D}$$

$$\text{Prop. band} = (100)\ (5)\ (0.83) = 35 \text{ percent}$$

$$\text{Reset} = \frac{1}{2\ T_D} = \frac{1}{2(0.083)} = 6 \text{ repeats/minute}$$

$$\text{Rate} = \frac{T_D}{2} = \frac{0.083}{2} = 0.042 \text{ minute}$$

Ultimate frequency data were used as a second method in determining optimum controller settings. Here the control loop is closed in order to acquire the necessary data. The recorder-controller was switched to automatic, and steady state conditions were reached using the same process variables as existed during the transient response runs; also initial controller settings were switched to zero rate and reset with a wide band; then the proportional band was gradually reduced (or loop gain increased) until the effluent water temperature began oscillating continuously. The system was allowed to operate at these "ultimate frequency" conditions through about ten cycles and then was shut down. It was then quite simple to measure the ultimate frequency of the oscillations which turned out to be 3.76 cycles per minute. The proportional band setting at these frequencies was 24 percent or a gain K_p of 100/24 equal to 4.6.

Using recommended ultimate frequency methods[1,5] optimum settings by the above techniques are as follows:

Two Mode Control (Proportional Plus Reset)

$$\text{Proportional band} = \frac{(PB)u}{0.45} = \frac{24}{0.45} = 53 \text{ percent}$$

$$\text{Reset rate} = 1.2\ F_u = (1.2)\ (3.76) = 4.5 \text{ repeats/minute}$$

Three Mode Control (Proportional Plus Rate Plus Reset)

$$\text{Proportional band} = \frac{(PB)u}{0.6} = \frac{24}{0.6} = 40 \text{ percent}$$

$$\text{Reset} = 2\ F_u = (2)\ (3.76) = 7.52 \text{ repeats/minute}$$

$$\text{Rate} = \frac{1}{8F_u} = \frac{1}{(8)\ (3.76)} = 0.053 \text{ minute}$$

Comparison of Methods. As far as ease in acquiring experimental data is concerned, the two methods are about the same. With the simple process used here, an accurate transient response curve was easily obtained because all process parameters remained constant except the one intentionally varied. With some existing loops, this might not be the case. In other instances, intentional oscillation of the controlled variables could be objectionable; so the method selected would depend on the circumstances at hand. The situation is usually such that one of the two methods can be used.

In order to compare calculated settings with experiments, control requirements had to be defined. In broad terms, best control may be defined as that which returns the controlled variable to the set point after a disturbance with minimum overshoot and cycling. The upset may be either in the form of a load change or a demand (set point) change. The testing method employed in determining the best controller settings consisted of suddenly changing water rate 25 percent either up or down. Control is ordinarily classed as excellent when the ratio of successive oscillations about the set point is 4/1 or more. In this case, good control was arbitrarily defined when these same ratios ranged in value from 3/1 to 2.5/1.

It was found that, for the subject equipment, the formulas tend to recommend reset rates that are somewhat high. In most every case, it was necessary to reduce reset values slightly below those calculated for the best control.

Table 3 summarizes calculated values with experimental results. It should be pointed out that, for the particular type of controller used, settings must be made in definite increments and are not continuously adjustable. Settings were selected as close as possible to calculated values. Here is the over-all summary of results:

TABLE 3
Transient Response Method

	PB Percent	Reset Reps/ Minute	Rate Minutes	Control Obtained
Two Mode	46	3.5	—	**Fair** on reduction of reset rate to 2.3 reps/ minute
Three Mode	35	6	0.042	**Good** on reduction of reset rate to 3.4 reps/ minute

Ultimate Frequency Method

	PB Percent	Reset Reps/ Minute	Rate Minutes	Control Obtained
Two Mode	53	4.5	—	**Fair** on reduction of reset rate to 3.4 reps/ minute
Three Mode	40	7.5	0.033	**Excellent** on reduction of reset rate to 5.8 reps/minute

It is seen that in every case a reduction in reset rate of about 25 percent was necessary in order to realize the most from the particular settings calculated by transient response and ultimate frequency methods. This is probably a particular characteristic of the make of controller and would not hold for all instruments.

In summarizing, both the transient response method and the ultimate frequency method for determining controller settings give comparable and satisfactory results. For temperature systems in general, control response is aided by addition of rate action. The best over-all results were obtained by use of three-mode control action calculated from ultimate frequency data. In many cases the methods recommended here for determining controller settings give faster and better results than does the usual trial and error approach. In any case, such data yield a wealth of information on the dynamics of a control system as will be explained.

Mathematical Analysis of Exchanger Dynamics. For advanced control methods involving computer control, it may become necessary to analyze a given loop with the idea of developing a reasonably accurate quantitative expression for the dynamics of the process. As will be shown, this is quite simple for an ordinary process where approximate linearity can be assumed. The analysis will be accomplished by using an analytical approach coupled with raw transient response data.

The first step is a dynamic energy balance over the exchanger (Figure 3).

Laboratory tests showed that the change in steam flow rate with control valve diaphragm pressure is almost linear:

$$\text{Steam flow rate} = \frac{4.00 - 0.76 \text{ lb./min.}}{10 - 4.2 \text{ psi}} = 0.56 \frac{\text{lb. steam}}{\text{min. psi}}$$

Heat added by a change in valve diaphragm pressure can be expressed as:

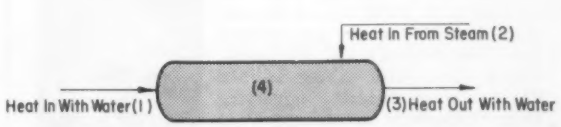
$$0.56 \frac{\text{pound}}{\text{min. psi}} \times (\text{r psi}) \times 1{,}000 \frac{\text{Btu}}{\text{pound}} = 560\,\text{r} \frac{\text{Btu}}{\text{min.}}$$

A dynamic energy balance over the exchanger can be accomplished by noting from the above sketch the points of heat input, output, and accumulation:

1. Heat in with water in small time increment (Δt), $= WC_p\Theta_i\Delta t$
2. Heat input from steam in small time increment (Δt), $= 560r\Delta t$
3. Heat output with water effluent in small time increment (Δt), $= WC_p\bar{\Theta}\Delta t$
4. Accumulation or small increase $\Delta\bar{\Theta}$ in exchanger water temperature in small time increment (Δt), $= V\rho C_p\Delta\bar{\Theta}$

$$\text{Accumulation} = \text{Input} - \text{Output}$$

$$V\rho C_p\Delta\bar{\Theta} = WC_p\Theta_i\Delta t + 560r\Delta t - WC_p\bar{\Theta}\Delta t \qquad (1)$$



Nomenclature

W = Water Flow Rate, Pounds / Minute
w = Water Flow Rate, Pounds / Second
U = Over-all Heat Transfer Film Coefficient
A = Area
C_p = Heat Capacity
Θ = Water Temperature (Super Bar Refers To Average Value)
V = Volume Occupied By Water In The Exchanger
r = Valve Diaphragm, PSI
t = Time, Minutes
ρ = Density, Pounds / Unit Volume

FIGURE 3—Scheme used for heat balance over the exchanger.

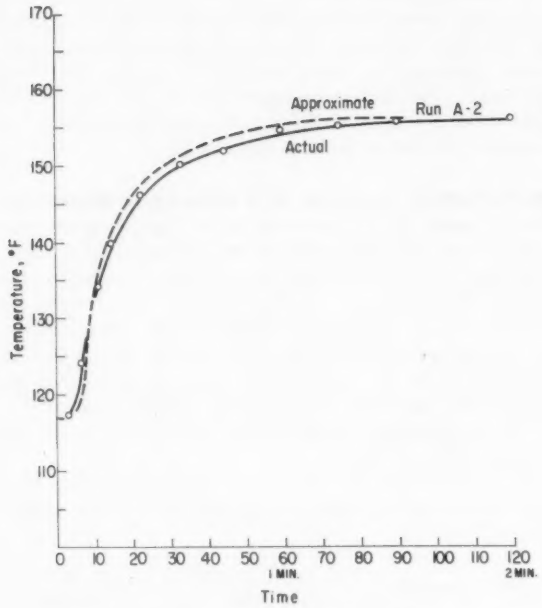


FIGURE 4—Equation derived (dotted line) compares well with actual transient response curve (solid line).

Dividing by $V\rho C_p \Delta t$ and letting $\Delta's \rightarrow 0$,

$$\frac{d\bar{\theta}}{dt} + \frac{W}{V}\bar{\theta} = \frac{W}{V}\bar{\theta}_i + \frac{560r}{V\rho Cp} \qquad (2)$$

and

$$T\frac{d\bar{\theta}}{dt} + \bar{\theta} = \theta_i + \frac{560r}{WC_p}, \text{ where } T = \frac{V\rho}{W} \qquad (3)$$

By using operator notation where d/dt = s, equation (3) can be transformed into:

$$T\theta s + \bar{\theta} = \frac{560r}{WC_p} \qquad (4)$$

About the Author

Fanning

Dr. Robert J. Fanning supervises development work on automatic control and computer applications for Continental Oil Company, Ponca City. After taking an MS degree in chemical engineering from University of Missouri, in 1947, he did pilot work in the Research and Development department of Phillips Petroleum Company. He then transferred to Phillips' butadiene and synthetic rubber plant in Borger as a process engineer. In 1955, he entered the University of Oklahoma to do graduate work in chemical and electrical engineering. After receiving his PhD in 1957, he joined Continental Oil Company.

The inlet water temperature Θ_i is assumed nonvariable and therefore can be dropped.

$$\text{Finally, } \frac{\bar{\theta}}{r}(s) = \frac{560/WC_p}{Ts + 1} \qquad (5)$$

Equation (5) is a simple first order transfer function which can be derived by a more expeditious method than the one used; however this expression assumes that the water temperature during a transient changes only with time, not distance. Such an assumption is not correct. Actually a partial differential equation is necessary to describe precisely what happens in the exchanger. The particular method of deriving the above equation was used because it can be consistently applied in the derivation of *all* types of differential equations.

It will now be shown that equation (5) with *adequate modification* by use of transient data satisfactorily describes the dynamics of the heat exchanger. First, the expression must be checked for steady state accuracy. It states that the effluent changes $560/WC_p$ degrees for each psi change in air to the steam flow valve. This amounts to 17.9° F/psi change. Experimentally, it was found that the water effluent changes 17.4° F for each psi change in air to the steam valve; thus very good static checks were obtained which would be expected in view of the fact that the original steam flow data were acquired by energy balance over the exchanger.

By considering exchanger tube volumes and flow rates, the time constant T turns out to be 0.13 minute or about 8 seconds. Inspection of the data will show that there is a short time period of about 3.5 seconds before a steam flow change registers in any way on a very sensitive temperature sensing system. Equipment geometry indicates that this can be called true time delay or pure dead time and can be mathematically expressed as exp (—3.5s) in operator notation. The transient curve as plotted in Figure 4 also shows that the curve has small but definite multilag qualities. The denominator of the process transfer function is then assigned another lag with a 1 second time constant based upon very rough calculations for the thermocouple shield.

Reducing all time units to a second rather than a minute basis, the final transfer function for the exchanger is:

$$\frac{\bar{\theta}}{r}(s) = \frac{\left(\frac{(9.3)}{(WC_p)}\right)\exp(-3.5s)}{(8s+1)(s+1)} \qquad (6)$$

Figure 4 shows the approximate dynamics of the process as described by equation (6) in comparison with the actual transient response curve shown as a solid line.

This work shows simple and speedy methods for acquiring a reasonably thorough knowledge of the dynamics of processes. Much more rigorous and elegant methods are available such as frequency response, pulse testing, and auto correlation techniques. In many cases, however, the simpler approach will provide information which is perfectly adequate for use in consideration of advanced process control systems.

LITERATURE CITED

[1] Coon, G. A., *Control Engineering*, 5, 66 (1956).
[2] Coon, G. A., *Control Engineering*, 6, 71 (1956).
[3] Drew, T. B., and Hoopes, J. W. in *Advances in Chemical Engineering*, Academic Press, Inc., New York, 1958.
[4] Laspe, C. G. in *Automation in Business and Industry*, John Wiley and Sons, Inc., New York, 1957.
[5] Zoss, L. M., *Control Engineering*, 1, 50 (1956).

FIGURE 1—Shows the location of petrochemical plants on the islands of Honshu, Kyushu and Shikoku Japan. Plants shown in parenthesis are not presently in production.

22. Nissan Chemical
27. Asahi Electrochemical
31. Shin Nippon Chisso
33. Toyo Koatsu
35. Nippon Petrochemicals
36. Toa Nenryo
37. Nihon Geon
38. Asahi-Dow
39. Furukawa Chemical
40. Nitto Chemical
41. Japan Catalytic Chemical Industry
42. Mitsubishi Petrochemical
43. Showa Denko
44. Asahi Chemical
45. Nippon Oils and Fats
46. Kokan Chemical
47. Kawasaki Chemical
53. Mitsubishi Yuka
54. Japan Synthetic Rubber
55. Mitsubishi Chemical Industries
56. Mitsubishi Monsanto
63. Mitsui Petrochemical
64. Dai-Nippon Celluloid
66. Ube Industries
67. Kyowa Fermentation
68. Tokuyama Soda
69. Sumitomo Chemical
70. Maruzen Oil
75. Mitsui Chemical
79. Idemitsu Kosan

Watch Japan's Petrochemical Growth

From these highlights of petrochemical activity in Japan you can see areas of imbalance and where extreme care will be needed in selecting and scheduling future plants

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SUCCESS OF JAPAN'S first petrochemical venture, launched in 1955, has engendered a flood of announced plans for further expansion in this field. Prior to this development, her organic chemical industry was based largely on acetylene from carbide, coke oven gas, natural gas, and coal mine gas.

Organics—Present and Future. Except for a few specific areas, mainly fertilizers and in recent years PVC, Japan's organic chemical products have not been a major factor in the world markets. Her low labor costs which are important in many manufacturing activities do not offset her relatively, and in some cases artificially, high chemical raw material costs.

On December 15, 1959, the Light Industries Bureau of MITI (Ministry of International Trade and Industry) published a statement of its "Policy on Petrochemical Industrialization Plans." The basic premise of this policy statement is to foster plans for systematically modernizing the chemical industry as a whole. MITI expects Japan to attain complete chemical self-sufficiency during

1962 at the equivalent of international C.I.F. (cost, insurance and freight) prices. They propose to do this by selecting from the latest available processes and integrating operations to balance out petrochemical production and derivatives.

This is indeed an ambitious goal. Currently available estimates of 1962 prices do not fully support the expectations; however, there can be little doubt that as the scale of operations increases and further integration and updating takes place, Japan's organic chemicals will become a more important factor in the world markets.

Based on 1955 to 1959 inclusive data, the Japanese economy advanced at an average, annual rate of 11.3 percent. The chemical industry showed a growth rate of 14.2 percent which was less than that shown by five other industries: machine, petroleum and coal products, rubber, iron and steel, and the nonferrous metals industry. However, within the chemical industry, synthetic resins and plastics showed a growth rate of 29.8 percent, and synthetic organics grew at an average annual rate of 26.1 percent during the 1955 to 1959 period.

In 1958 the chemical industry accounted for 11.2 percent of the shipments made by all of the manufacturing industries in Japan. This amount was exceeded only by the textile and food industries. On the basis of added value the chemical industry was highest, accounting for 12.6 percent of the total for all manufacturers.

Table 1 shows the indices of production for various segments of the chemical industry for 1956 to 1959 inclusive, compared with an index of 100 for 1955. The indices, on the same basis by month for January to June, 1960, inclusive, indicate the rapid continuing growth as well as, in some cases, the seasonal influences.

Tables 2 to 5 inclusive present a summary listing of major chemical products giving present capacities and planned additional capacities as of July 31, 1960. In addition, the varying degrees of realizability for the planned ethylene projects are presented. The realizability is classified under five categories as follows:

A. Project approved by Government or plant under construction.

B. Application filed or construction plan is concrete.

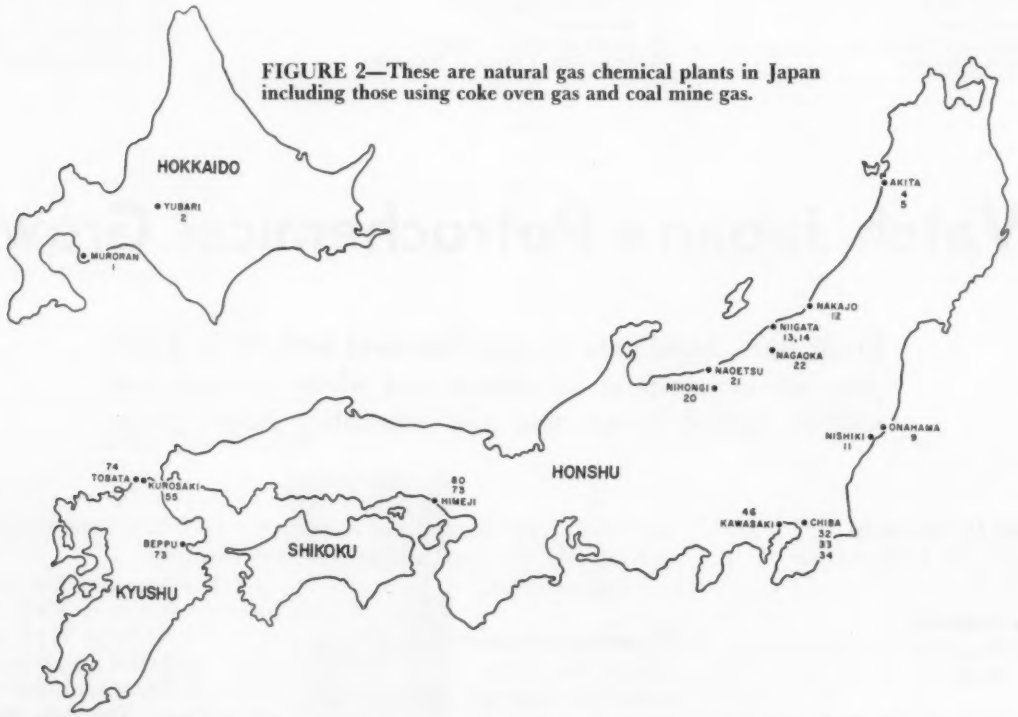
C. Introduction of technique being negotiated or completed.

D. Plan only.

—Indicates information not available as of July 31, 1960.

Japanese Industrial Atmosphere. A look at some of the characteristics of Japan that differ somewhat from those of the United States will illustrate the present activities. In Japan, all new projects that will need a validation of remittance of foreign exchange have to be approved by a Government agency, generally MITI. Most petrochemical projects will fall in this category

FIGURE 2—These are natural gas chemical plants in Japan including those using coke oven gas and coal mine gas.



1. Joint Venture of Toyo Koatsu and Fuji Steel
2. Mitsubishi Mining
4. Akita Petrochemical
5. Tohoku Fertilizer
9. Japan Hydrogen
11. Kureha Chemical
12. Kyowa Gas-Chemical
13. Toyo Gas-Chemical
14. Japan Gas-Chemical
20. Japan Soda
21. Shin-Etsu Chemical Industry
22. Nissan Chemical
32. Asahi Glass
33. Toyo Koatsu
34. Kawtetsu Chemical
46. Kokan Chemical
55. Mitsubishi Chemical Industries
73. Befu Chemical
74. Yawata Chemical
80. Seitetsu Chemical

FIGURE 3—Here's where Japan's carbide, ammonia and methanol plants are located. Those using coke oven gas and natural gas are not shown.

3. Iwakura-Gumi
6. Tekkosha
7. Tohoku Electric Steel
8. Matsukawa Coal
9. Japan Hyrogen
10. Kureha Chemical
15. Niigata Electric
16. Tohoku Kaihatsu
17. Hokuetsu Electric Chemical
18. Japan Carbide
19. Tokai Electrode
21. Shin-Etsu Chemical Industry
22. Nissan Chemical
23. Daihoku Industry
24. Nisshin Chemical
25. Electric Chemical
28. Edogawa Chemical
30. Sumitomo Bakelite
31. Shin Nippon Chisso
33. Toyo Koatsu
37. Nihon Geon
40. Nitto Chemical
43. Showa Denko
48. Dainippon Paint
49. Yutaka Formalin
50. Toa Gosei Chemical
51. The Toho Chemical Industries
52. Ibigawa Denki
55. Mitsubishi Chemical Industries
56. Mitsubishi Monsanto
57. Tokai Ryuan
59. Japan Resin Chemical
60. Kanegafuchi Chemical
61. Koei Chemical
64. Dai-Nippon Celluloid
65. Toyo Soda
66. Ube Industries
67. Kyowa Fermentation
69. Sumitomo Chemical
72. Toyo Electro Chemical
73. Befu Chemical
77. Nippon Gosei

since they will require foreign exchange for the purchase of know-how or engineering services, or for the importation of special equipment. In the course of negotiation for the approval of new projects, proposed product and capacity figures become public knowledge. This situation accounts for the availability of much of the extensive tabulation of planned activities shown.

One of the prime factors that modifies and slows down the execution of plans is the need for Government approval of new projects. The negotiations with the Government agencies always require months, and may, in some cases, require years. Some plans will never get Government approval, while others will be markedly modified. Thus, the multiplicity of plans undergo many changes and delays before reaching the point of fulfillment.

Petrochemical Program. Table 6 is a tabulation showing the consumption of basic petrochemicals in Japan in 1958 and 1959, and estimates of the amounts that will be consumed in 1960, 1965, and 1970. Comparisons with respect to individual products in Tables 2 and 3 with Table 6 will show considerable variation in the degree of forward planning with respect to the presently estimated needs of the future. It can be seen in the case of ethylene, for example, that present plans would more than satisfy the currently estimated needs of 1970. The achievement of production plans in excess of her estimated domestic needs could presage the entry of Japan's organic chemicals into world markets. However, it seems to be the general consensus that Japan will not be in a competitive position on such things as polyethylene for another five years.

The polyethylene situation in

TABLE 1—Production index classified by industry (monthly avg.: 1955 = 100).

	1956	1957	1958	1959	1960					
					Jan.	Feb.	Mar.	Apr.	May	June
Synthetic fibers	182	270	294	512	670	666	736	747	776	748
Synthetic resins and plastics	145	204	191	284	334	335	363	357	378	383
Synthetic organics	138	164	180	254	289	302	331	306	332	351
Tar products	124	130	142	197	236	237	270	225	267	256
Paints	126	142	149	183	178	185	201	207	210	213
Total chemical industry	121	135	137	168	181	183	202	199	209	197
Textile industry	119	131	118	138	146	157	158	161	161	166
Chemical fertilizers	114	120	129	140	144	139	164	169	177	140
Food industry	106	111	118	124	143	207	223	107	111	110

Note: Index figures for 1956 to 1959 are the monthly averaged production.

Watch Japan's Petrochemical Growth . . .

TABLE 2—Ethylene plants with capacities in 1000 metric tons/year.

No.	Present	Planned	Realizability	Raw Material	Furnisher of Technique	Completion Date
4	79	....	..	Naphtha	Stone & Webster	.....
1	..	22	A	Naphtha	Stone & Webster	June 1961
1	..	16.5	A	Naphtha	Soc. Belg. L'Azote	June 1961
1	..	25	B	Naphtha	Stone & Webster	Mar. 1961
1	..	62	B	Naphtha	Esso	End 1961
1	..	60	B	Naphtha	Stone & Webster	Jan. 1961
1	..	44	B	Naphtha	Lurgi	June 1962
1	..	26.5	C	Naphtha	Stone & Webster	1962–1963
1	..	41.3	C	Naphtha	Stone & Webster	.....
1	..	2	C	C. O. G.	.....	.....
1	..	50	D	Naphtha	Stone & Webster	1963–1965
1	..	11.2	D	Naphtha	Montecatini	.....
1	..	34.8	D	Naphtha	Stone & Webster	.....
1	..	21.2	D	Naphtha	Koppers	.....
1	..	38	..	Naphtha	Stone & Webster	Mar. 1962
1	..	100	..	Naphtha	.....	.....
1	..	9	..	C. O. G.	Linde	.....
1	..	1.8	..	C. O. G.	.....	.....
21	87	565.3				

TABLE 4—Number of ammonia plants with capacities in 1000 tons/year.

No.	Present	Planned	RAW MATERIAL: Present and New Plants	RAW MATERIAL: After Rationalization	FURNISHER OF TECHNIQUE: Synthesis Gas	FURNISHER OF TECHNIQUE: Ammonia Synthesis
1	116.3	.....	Coal	.....	Winkler	Claude
				Crude Oil	Winkler	Claude
2	71.1	.....	Natural gas	.....	½ own Grande Paroisse	New Claude
1	21.4	—21.4	Coke	.....	.....	.....
1	117.7	—16.6	Coke and C. O. G.	.....	Koppers	Claude
				Crude oil	Texaco	Claude
1	44.5	.....	Water and Coke	.....	Electrol.	I. G.
				Crude oil	Texaco	I. G.
1	42.4	.....	Coke	.....	.....	I. G.
				Crude oil	Texaco	I. G.
1	35.0	.....	Natural gas	.....	Fauser	New Uhde
1	47.1	.....	Coal and natural gas	.....	Koppers	New Uhde
				Crude oil	85% own Chem. Constr. Corp.	New Uhde Chem. Constr. Corp.
2	100.8	.....	Natural gas	.....		
1	142.6	.....	Water Crude oil Waste gas	.....	Electrol. and Texaco	Tokyo Inst. of Tech.
				C. O. G.	½ Linde	Tokyo Inst. of Tech.
1	36.8	.....	Natural gas	.....	Fauser	New Fauser
1	82.4	—36.8	Water Crude oil	.....	Electrol. Fauser	.....
1	47.7	.....	Water Coal Coke	.....	Electrol. Winkler	Uhde
				Crude oil	60% Sumitomo Electrol.	Uhde
1	36.6	.....	Water Crude oil	.....	Fauser	Fauser
				Crude oil	Shell	Fauser
1	74.1	—40.0	Coke Crude oil	.....	Texaco	New Fauser
1	105.3	.....	Crude oil Coal	.....	Texaco Koppers	New Fauser
				Crude oil	Texaco	New Fauser
1	45.0	.....	Crude oil	.....	Fauser	New Fauser
				Crude oil	Shell	New Fauser
1	147.1	.....	Crude oil Waste gas	.....	Sumitomo Grande Paroisse	Nitrogen Eng. Corp.
1	119.7	.....	Coal C. O. G.	.....	Winkler Fauser	New Fauser
				C. O. G.	Fauser	New Fauser
1	39.7	.....	Water Crude oil	.....	Electrol. Fauser	Casale
				C. O. G.	Claude	Casale
1	18.0	.....	Crude oil	.....	Texaco	Casale
2	.....	71.9	Natural gas	.....	Grande Paroisse	New Claude
1	.....	35.0	Natural gas	.....	Chem. Constr. Corp.	New Uhde
1	.....	44.7	C. O. G.	.....	Linde	I. G.
1	.....	40.6	C. O. G.	.....	Linde	.....
1	.....	32.9	Crude oil	.....	Shell	New Fauser
2	.....	65.8	Crude oil	.....	Texaco	New Fauser
3	.....	306.0	C. O. G.	.....	.....	.....
34	1491.3	482.1 net.				

TABLE 3—Present and planned capacities in 1000 metric tons/year and number of plants for major products.

	No.	Present	Planned
Propylene	15	63.5	348.6
Butylene*	14	66.6	212.7
Benzene	9+	109.5	61.5
Toluene	7+	47.4	50.4
Xylene	7+	32.8	33.5
Methanol	17	207.9	229
Formalin	18	204.1	60.6
Calcium carbide	26	1887	53
Acetylene (Petroleum source)	5	.....	48.8

* The butylene estimates should be interpreted as the butylene equivalent of butylene, butane, and of butadiene extracted directly from cracked hydrocarbon streams.

TABLE 5—Number of urea plants with present and planned capacities in 1000 metric tons/year.

No.	Present	Planned	Process
5	418.4	...	Toyo Koatsu
6	239.0	...	Fauser
2	120.7	...	Chem. Constr. Corp.
1	32.9	...	Nitto
2	....	100	Fauser
1	....	60	Toyo Koatsu
17	811.0	160	

TABLE 6—Actual and estimated petrochemical consumption in 1000 metric tons/year.

Product	1958	1959	ESTIMATED 1960	1965	1970
Ethylene	14	44	84	320	510
Propylene	3	10	25	240	470
Butylene*	3	7	49	190	360
Benzene	66	92	130	240	370
Toulene	22	45	56	100	140
Xylene	10	20	52	120	190

* The butylene estimates should be interpreted as the butylene equivalent of butylene, butane, and of butadiene extracted directly from cracked hydrocarbon streams.

Japan presents an example of the intense competition between companies to gain Government approval for desired projects. At present there are five polyethylene plants in Japan. The techniques of I.C.I. and BASF are used for the low-density plants, Phillips and Standard Oil of Indiana for medium density, and Ziegler for the high-density polyethylene plant. The total rated capacity of these five plants is 52,000 metric tons/year. Seven companies have plans in various stages of progress for low-density polyethylene plant expansions or new plants that would add 240,500 metric tons to the present capacity. An additional 10,000 metric-ton Phillips medium-density plant is scheduled for completion in December, 1961. If all of the present plans for additional polyethylene capacity were approved and the plants were built, the total capacity would be 302,500 metric tons/year. Contrasted to this, the current estimate for polyethylene production in 1970 is 190,000 metric tons.

The ammonia process changes shown in Table 4 illustrate some of the progress being made in modernizing Japan's chemical industry. The ammonia synthesis being used in one of the larger installations was

developed by the Tokyo Institute of Technology. The changes in hydrogen sources are summarized in Table 7.

Petrochemical derivatives. Tables 8 through 16 tabulate the production of major derivatives for 1958 and 1959 and estimated production in 1960, 1965, and 1970. In looking at the highlights of these tabulations, it is interesting to note that due to a protective policy for agricultural products, all ethyl alcohol is now made by fermentation. It is assumed that by 1970 it will be made synthetically. The coming tendency to shift from an acetylene to an ethylene route is illustrated by the 1965 and 1970 estimates for the production of acetaldehyde and of ethylene dichloride used mainly for vinyl chloride. These raw material shifts characterize the change to a petrochemical economy.

C_3's and C_4's—While propylene derivatives have a foothold in Japan, it will be some time before an effective and balanced use can be made of the C_3 and C_4 fractions resulting from cracking operations. Butadiene, the principal C_4 product, is made mainly from butane by the Houdry process, with some being obtained by extraction from cracked products.

Aromatics—Most of Japan's benzene still comes from by-product coke plants or from imports. Three companies have Udex units in operation, and many more are planned. As the increasing demand for benzene is met from petroleum sources, toluene and xylene may become a problem. The growth of polyester fibers is increasing the demand for terephthalic acid. With growing needs for plasticizers, phthalic anhydride production is expected to show an average annual growth rate of 11 percent between 1960 and 1970. It is outgrowing the available supply of naphthalene, and production from *o*-xylene is just starting.

TABLE 7—Changes in H_2 sources for NH_3.

Hydrogen Source	1960	1963
Electrolytic	11%	2.5%
Coal and coke	32%	3.5%
Fluid sources:	57%	94%
(crude oil)	(25)	(45)
(natural gas)	(15)	(21)
(coke oven gas)	(10)	(18)
(waste gas)	(7)	(10)
	(57)	(94)

TABLE 8—Actual and estimated production of major ethylene derivatives in 1000 metric tons/year.

			ESTIMATED		
Product	1958	1959	1960	1965	1970
Ethylene oxide	2	7	18	42	68
Polyethylene	10	21	45	120	190
Syn. ethanol	..	...	...	35	50
Acetaldehyde (total)	75	103	140	210	260
Acetaldehyde (ethylene)	..	...	...	50	110
Styrene monomer	..	10	43	94	160
Ethylene dichloride	..	...	...	86	160
Ethyl chloride	..	...	...	5	6
Ethylene dibromide	..	...	0.7	4	6

TABLE 9—Actual and estimated production of major propylene derivatives in 1000 tons/year

			ESTIMATED		
Product	1958	1959	1960	1965	1970
Propylene oxide	..	0.3	3	25	45
Polypropylene	..	..	..	46	200
Acrylonitrile (total)	0.7	13	20	44	61
Acrylonitrile (Sohio proc.)	..	..	..	24	41
Isopropyl alcohol	3	7	9	17	35
Alkylbenzene	..	..	..	41	60
Cumene	0.5	18	21	45	45
Synthetic glycerine	..	..	..	15	30
Epoxy resins	..	..	..	4	10
2-Ethyl hexanol	..	..	4	16	36
Isobutanol	..	..	1	8	24

TABLE 10—Actual and estimated production of major butylene derivatives in 1000 tons/year

			ESTIMATED		
Product	1958	1959	1960	1965	1970
Butadiene*	..	1	27	100	200
sec-butanol	3	6	9	13	17
Butyl rubber	..	..	..	11	14
Polybutenes and Polyisobutylene	..	..	..	3	4

* The butadiene estimated will actually be made from both butylene and butane, and some will be obtained by extraction of cracked gas streams.

Table 11—Actual and estimated production of major benzene derivatives in 1000 tons/year

			ESTIMATED		
Product	1958	1959	1960	1965	1970
Paint solvents	14	5	..	..	..
Styrene monomer	...	10	43	94	160
Phenol (total)	26	37	53	71	64
Phenol (from benzene)	24	35	50	57	48
Phenol (from toluene)	...	..	..	10	11
Phenol (distilled natural)	2	2	3	4	5
Nylon (total)	23	31	40	58	75
Nylon (direct method)	2	3	3	29	70
Alkylbenzene	...	..	..	41	60
D.D.T.	0.7	1	1	1	1
B.H.C.	11	14	15	16	18
Aniline	7	8	8	11	13
Maleic anhydride	2	3	4	5	7

TABLE 12—Actual and estimated production of major toluene derivatives in 1000 tons/year.

			ESTIMATED		
Product	1958	1959	1960	1965	1970
Solvents	11	24	34	59	82
Mixed solvents	3	5	10	18	25
Polyurethane	..	..	1	10	25
Phenol	..	..	..	10	11

TABLE 13—Actual and estimated production of major xylene derivatives in 1000 tons/year.

			ESTIMATED		
Product	1958	1959	1960	1965	1970
Terephthalic acid (by S.D. method)	0.9	8	12	36	64
Terephthalic acid (total incl. from naphthalene	2	11	17	45	80
Phthalic anhydride (o-xylene)	..	..	12	33	60
Phthalic anhydride (total incl. from naphthalene)	20	38	48	74	110
Solvents	7	9	18	30	42
Mixed solvents	0.9	3	12	20	28
Others	2	3	3	11	18

TABLE 14—Actual and estimated production of major methanol derivatives in 1000 tons/year.

			ESTIMATED		
Product	1958	1959	1960	1965	1970
Formalin	118	159	180	320	460
Methyl chloride	0.6	1	1	1	2
Methylene chloride	2	2	2.8	5	7
Methacrylate resin	1	2	3	6	10
P.V.A.	16	22	27	63	110
Tetron	3	14	20	50	90

TABLE 15—Actual and estimated production of major formaldehyde derivatives in 1000 tons/year.

			ESTIMATED		
Product	1958	1959	1960	1965	1970
Phenolic resins	18	30	33	63	79
Urea resins	82	107	130	220	330
Melamine resins	7	9	10	25	39
Vinylon	13	17	20	27	27
Urotropin	2	3	3	5	7
Pentaerithritol	0.9	1	1	6	7

TABLE 16—Actual and estimated production of major acetylene derivatives in 1000 tons/year.

			ESTIMATED		
Product	1958	1959	1960	1965	1970
PVC (total)	92	180	280	450	600
PVC (acetylene)	92	180	280	400	510
Vinyl acetate	40	54	77	120	160
Tri-and Perchloroethylenes	13	14	16	20	30
Neoprene	...	...	...	14	19
Acrylonitrile (total)	0.7	13	20	44	61
Acrylonitrile (from acetylene)	0.7	13	20	20	20
Acetaldehyde (total)	75	103	140	210	260
Acetaldehyde (from acetylene)	75	103	140	160	150

Watch Japan's Petrochemical Growth . . .

TABLE 17—Actual and estimated production and use of calcium carbide in 1000 tons/year.

Product	USE		ESTIMATED USE		
	1958	1959	1960	1965	1970
Acetylene for organic syn.	351	584	690	850	810
Acetylene for other uses	151	178	200	230	390
For calcium cyanamide for fertilizers	305	251	300	300	300
For export	17	11	...	...	...
Inventory change	65	(75)	30	...	...
Total production	889	949	1220	1380	1500

TABLE 18—Production and disposition of PVC shown in 1000 tons/year.

	1955	1956	1957	1958	1959
Production	32	56	109	92	180
Imports	0.2	0.7	0.5	0.1	0.4
Exports	3	3	3	17	31
Inventory changes	—0.3	—0.2	9	—7	—0.6
Domestic consumption	30	54	94	81	150

TABLE 19—Production and use of ammonia shown in 1000 tons/year.

	USE		ESTIMATED USE		
	1958	1959	1960	1965	1970
For Fertilizers	1001	1066	1060	1500	1700
(Ammonium sulfate)	(641)	(638)	(640)	(600)	(500)
(Urea)	(273)	(328)	(330)	(600)	(700)
(Others)	(87)	(100)	(90)	(300)	(500)
For chemical raw material other than fertilizers	119	148	200	300	500
Total production	1120	1214	1260	1800	2200

TABLE 20—Production and disposition of ammonium sulfate and urea in 1000 tons/year.

	1955	1956	1957	1958	1959
Ammonium sulfate					
Production	2129	2323	2481	2610	2634
Export	414	476	717	818	1035
Inventory increase	52	125	49	57	3
Domestic use	1663	1722	1715	1735	1596
Urea fertilizer grade					
Production	158	242	343	447	523
Export	...	60	112	167	307
Inventory change	8	7	6	11	—34
Domestic use	150	175	225	269	250
Urea Industrial grade					
Production	14	20	22	24	35
Domestic use	14	20	22	24	35

Methanol—Until 1951 methanol was made exclusively from water gas. Since then there has been a shift until 64 percent is now made from natural gas, which is a cheaper raw material. The continuing growth of resins promises a good future for methanol and formaldehyde, especially if the polyformaldehyde resins should get underway.

Changing Organic Picture

Acetylene—Following World War I, calcium carbide manufacture developed gradually for the production of fertilizers. Some carbide acetylene was used for organic syntheses, and after World War II, carbide capacity was expanded rapidly to supply acetylene for this purpose. The industry is dependent on seasonal surplus power generated by flowing water without the use of dams. Of the 948,000 metric tons produced in 1959, 762,000 metric tons were used to generate acetylene. The average production rate was only 48 percent of rated capacity; an average rate of 70 percent is considered to be the maximum that is likely to be reached. With insufficient surplus power and rising power costs, there are a number of announced plans for petrochemical-source acetylene. As ethylene and propylene prices are reduced, some of the acetylene-based products will shift to other methods of production. Table 17 shows the production and use of calcium carbide in 1958 and 1959, and the estimated production and use in 1960, 1965, and 1970.

Vinyl Chloride—All vinyl chloride is now made from acetylene. There are a number of plans for plants using the ethylene-EDC route. PVC seems to be the number one plastic of Japan. It is estimated that it will account for 46 percent of all the synthetic resins made in 1960. The combination of raw material availability, usefulness, and price has resulted in a remarkable growth in the production of PVC. Since the latter part of 1957, Japan's PVC has become increasingly important in world markets both from the standpoint of quantity and particularly price. From current estimates of future production it is likely to appear in increasing quantities. Table 18 shows the production and disposition of PVC in 1955 to 1959 inclusive.

Japan's ammonia derivatives are large tonnage export items. Over 1 million metric tons of ammonium sulfate were exported in 1959. This product is known as a "red-ink" export. Domestic use is declining, and with the industrialization of underdeveloped countries, exports will tend to reach a ceiling. This is a declining industry and no additions to present capacity are anticipated. Table 19 shows the production and use of ammonia in 1958 and 1959, and the estimated uses in 1960, 1965, and 1970. Table 20 shows the production and disposition of ammonium sulfate and urea in 1955 through 1959.

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About the Authors

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Still growing fast . . .

Chlorinated Hydrocarbons

Allyl chloride, new high polymers, and vinyl chloride point to increasing demand for these versatile petrochemicals. New technology and production methods indicate most new plants will be based on petroleum derived methane, ethylene, and acetylene

R. K. Treichler, The Dow Chemical Company
Freeport, Texas

A BRIGHT FUTURE is predicted for the chlorinated hydrocarbon industry. Certainly some of the products will eventually fall by the wayside; others will have their production rates level off. Products which still have tremendous growth prospects are: (1) allyl chloride (expanding because of epoxy resin demand and the emphasis being placed on glycerine based polyurethane, and polyester resins; (2) the high polymers of fluorocarbons which are based on chlorinated hydrocarbons and (3) vinyl chloride which is just catching on in this country for structural and building materials.

A 1970 production of approximately 4.5 billion pounds per year of chlorinated hydrocarbons, or an increase of 1.3 billion pounds per year over the production in 1960, can be anticipated (Figure 1). At least 800 million pounds of this increased capacity will come from Gulf Coast installations.

PRODUCTION METHODS

When studying chlorinated hydrocarbon production methods and the

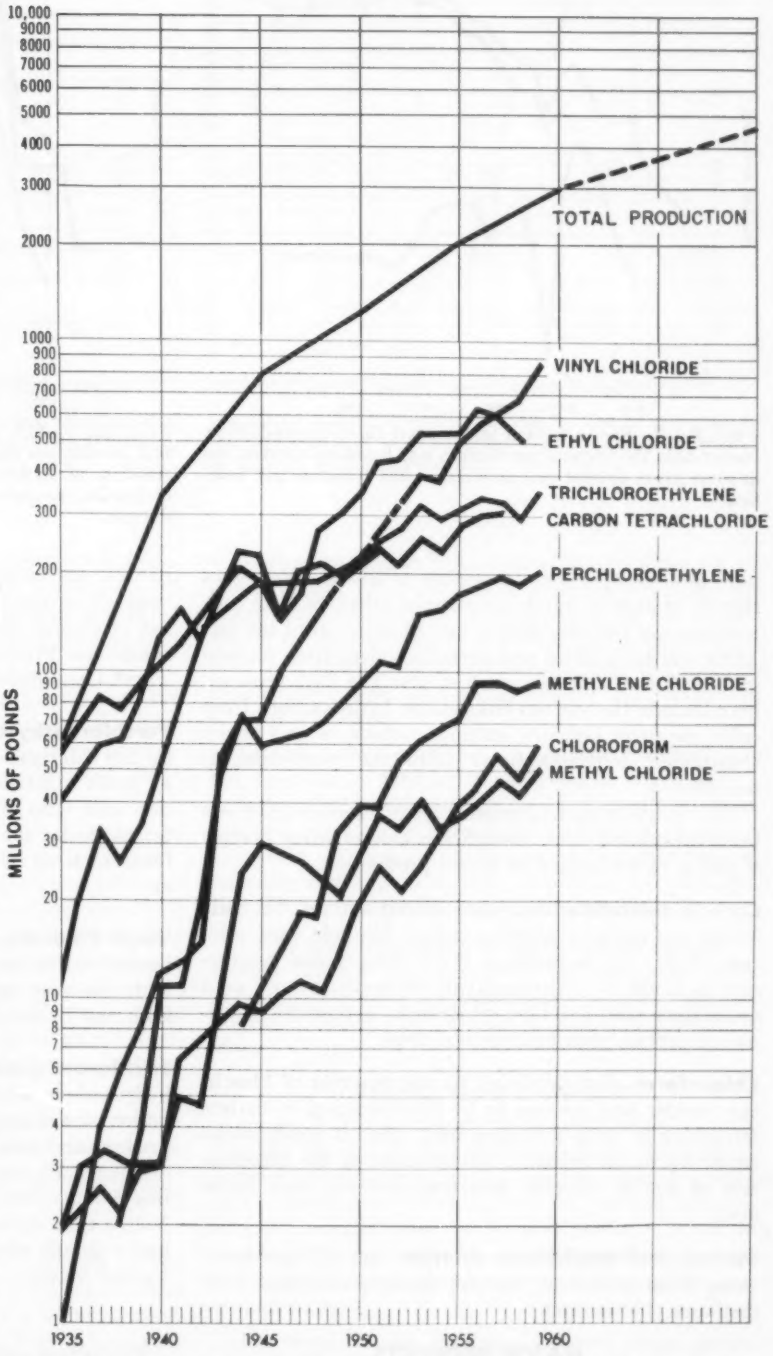

FIGURE 1—Here's how the various compounds fit into the overall picture. Notice that only ethyl chloride shows a definite down trend.

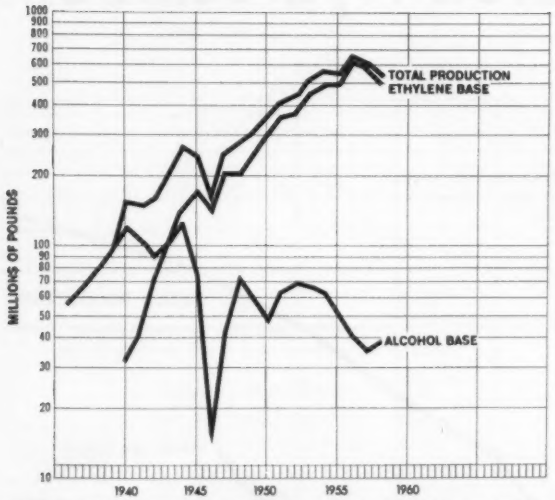

FIGURE 2—Shows United States ethyl chloride production. Notice that the original production was based on alcohol and in some areas alcohol raw material is still economically justified.

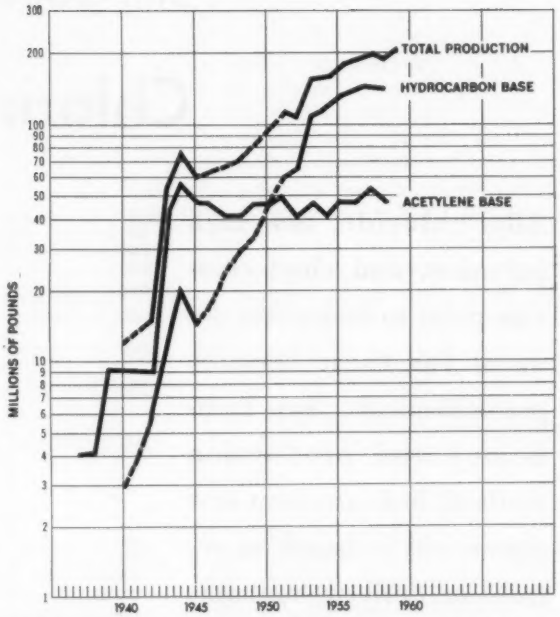

FIGURE 3—U.S. perchloroethylene looks like this with original production based on acetylene. However, thermal chlorination of hydrocarbon feeds such as methane, ethylene dichloride, propylene, etc. now accounts for the major production.

new and cheaper raw materials available, one point should be kept in mind: commercial ethylene from natural gas was not available in any quantity until the late 1930s and early 1940s and cheap acetylene from natural gas is still in the development stages. The data reported here include the various chlorinated hydrocarbons from coke, the sugar industry, calcium carbide, as well as the chlorinated hydrocarbons from the petrochemical sources.

The ethylene and propylene glycol families have not been considered here, though the chlorohydrin process is still a major source of glycol production.

Carbon tetrachloride, when introduced in the early 1900s, was made by reacting carbon bisulfide with chlorine. Today the majority of the United States' production is made by chlorination of methane, or as a co-product with perchloroethylene in a thermal chlorination process with hydrocarbon feed.

Chloroform, first produced by the reaction of bleaching powder and acetone or by the reduction of carbon tetrachloride with hydrogen and iron, is made today either by the chlorination of methane or the chlorination of methyl chloride, previously derived from methanol.

Methyl and methylene chloride are still produced today from methanol, but the major production is by methane chlorination.

MAJOR PRODUCTS

Ethyl Chloride. The original production (Figure 2) was based on ethyl alcohol. When ethylene from the natural gas became available, new facilities were constructed to use this new raw material. Notice alcohol use continues today but only where justified by local conditions. Production data in this article is from U.S. Tariff Commission reports.

Perchloroethylene (Figure 3) originally was produced by the chlorination of acetylene-derived trichloroethane to penta chlorethane and subsequent dehydrochlorination with lime to perchloroethylene. Now it is produced primarily by the thermal chlorination of hydrocarbon feeds such as methane, ethylene dichloride, propylene, etc.

Vinyl Chloride, based on ethylene raw material was introduced in the late 1940s (Figure 4), but in contrast with the two previous products, the production from both raw materials is still growing.

Trichloroethylene, is the only commercial chlorinated-hydrocarbon which remains tied to acetylene for the major part of its production. Acetylene is the same basic product and raw material from which it was produced originally. Figure 5 points out the impact of imports on this product, not a change in manufacturing techniques. Notice that during the last several years imports have had a drastic effect on the growth of production in the United States.

PLANT LOCATIONS

Production centers for these products have changed with the advances in process knowledge and new raw materials. Figure 6 shows what has happened since 1940.

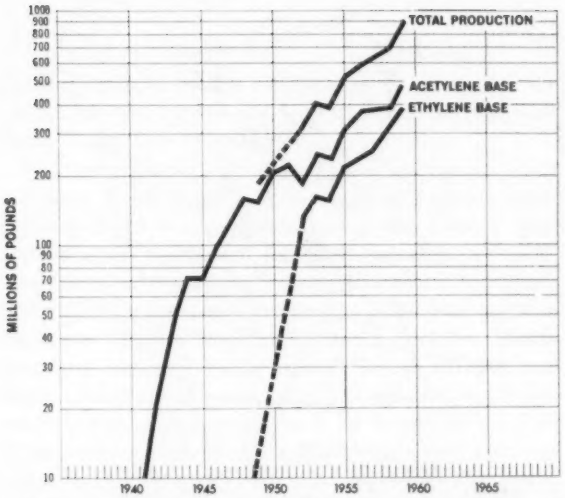

FIGURE 4—Notice the competition between acteylene and ethylene for vinyl chloride production with both growing rapidly.

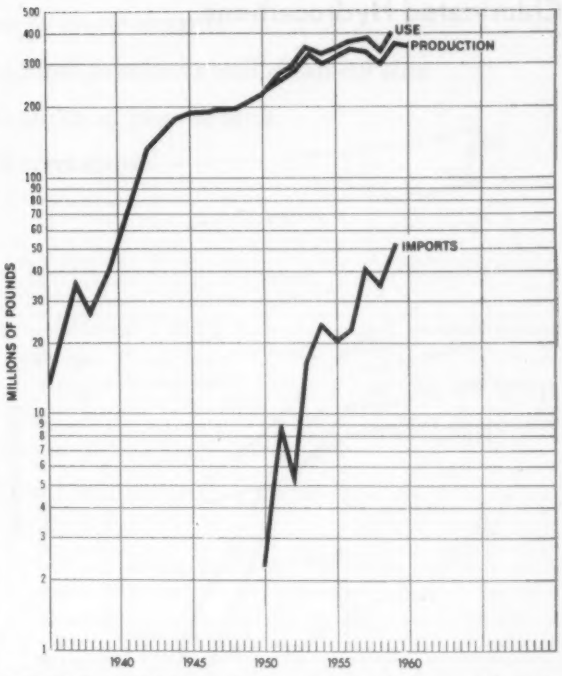

FIGURE 5—Trichloroethylene remains tied to acetylene for the major part of its production. However, notice the effect of imports on U.S. production.

By 1940 the total United States capacity for the production of chlorinated hydrocarbons was made up of 18 major plant sites in 13 cities. Of these only the Ethyl Corporation in Baton Rouge was located on the Gulf Coast.

One production location, Pittsburg, Calif., was the only plant then producing chlorinated hydrocarbons from natural gas based raw material. All other production was based on alcohols, calcium carbide based acetylene, carbon disulfide, and the like.

By 1950 the total number of plant sites increased to 27 in 19 cities, with the major growth on the Gulf Coast. Of the new plants, Dow at Freeport, Jefferson Chemical at Port Neches, Monsanto at Texas City, and Shell Chemical in Houston were using natural gas bases for these new products. Also Ethyl Corporation's Baton Rouge plant and Dow at Midland were switching part of their production to natural gas base. The Gulf Coast attracted these new plants because of abundant fuel, plentiful LPG feedstock, numerous salt domes, and the availability of water transportation.

By 1960 the number of plant sites increased to 40 in 29 cities. This growth resulted for three major reasons.

1. The use of methane as raw materials in the Ohio River area.

2. The expansion of vinyl chloride capacity in the Ohio River area by installing thermal cracking facilities to dehydrochlorinate ethylene dichloride to vinyl chloride and anhydrous hydrochloric acid. This will balance the hydrochloric acid needs on existing acetylene facilities for the production of vinyl chloride.

3. The installation of acetylene-HCl facilities for the production of vinyl chloride in localities where existing plants were modernizing their facilities for the production of trichloroethylene, making anhydrous hydrochloric acid a by-product rather than essentially throwing the hydrochloric acid away by cracking the tetrachloroethanes with lime.

Notable examples of this are General Tire and Rubber Company's Ashtabula, Ohio plant, which gets its anhydrous hydrochloric acid from Detrex's trichloroethylene facilities in Ashtabula, Ohio; and Goodrich's Louisville (Kentucky) plant, which installed thermal cracking facilities to balance the older acetylene-HCl facilities for the production of vinyl chloride.

Today there are some 44 major plant locations in the United States in 31 cities, producing chlorinated hydrocarbons. In 1960 these installations produced approximately 3,250,000,000 pounds of chlorinated hydrocarbons.

PRODUCTION CAPACITY

Figure 7 shows United States production capacity. The top line shows the summation of the published capacities for the production of chlorinated hydrocarbons and includes some plant capacity in stand-by condition only. It includes other plants that probably never will be run at design capacity again, because cheaper raw materials are available to produce the product more economically.

The second curve in Figure 7 shows actual production of chlorinated hydrocarbons over the same period as the top curve. The lower two curves show the pro-

Chlorinated Hydrocarbons . . .

FIGURE 6—Here are the locations of chlorinated hydrocarbon plants in the United States.

In 1940, these plants were in operation: □

1. Ansual—Marinette, Wisc.
2. Brown—Berlin, N. H.
3. Diamond Alkali—Painesville, Ohio
4. Dow Chemical—Midland, Mich.
5. Dow Chemical—Pittsburg, Calif.
6. Du Pont—Deep Water, N. J.
7. Du Pont—Niagara Falls, N. Y.
8. Du Pont—Wyandotte, Mich.
9. Ethyl Corporation—Baton Rouge, La.
10. Food Machinery—South Charleston, W. Va.
11. General Electric—Waterford, N. Y.
12. Goodrich—Calvert City, Ky.
13. Goodrich—Niagara Falls, N. Y.
14. Hercules Powder—Hopewell, Va.
15. Hooker—Niagara Falls, N. Y.
16. Stauffer—Niagara Falls, N. Y.
17. Union Carbide—South Charleston, W. Va.
18. Wyandotte—Wyandotte, Mich.

In 1950 the following plants had come into operation: ○

19. Dow Chemical—Freeport, Texas
20. Dow Corning—Midland, Mich.
21. Goodrich—Louisville, Ky.
22. Hooker—Tacoma, Wash.
23. Jefferson Chemical—Port Neches, Texas
24. Monsanto—Texas City, Texas
25. Shell Chemical—Houston, Texas
26. U.S. Rubber—Painesville, Ohio
27. Union Carbide—Texas City, Texas

In 1960 these plants were added to the list: △

28. Allied Chemical—Moundsville, W. Va.
29. American Chemical—Watson, Calif.
30. Columbia Southern—Barberton, Ohio
31. Diamond Alkali—Bell, W. Va.
32. Diamond Alkali—Deer Park, Texas
33. Dow Chemical—Plaquemine, La.
34. Detrex—Astabula, Ohio
35. Ethyl Corporation—Houston, Texas
36. Frontier Chemical—Wichita, Kan.
37. General Tire and Rubber—Astabula, Ohio
38. Kolker Chemical—Newark, N. J.
39. National Petrochemical—Tuscola, Ill.
40. Stauffer—Louisville, Ky.

By 1961, these plants were planned or soon to become operational:

41. Columbia Southern—Lake Charles, La.
42. Monochem—Geismar, La.
43. Olin Mathieson—Doe Run, Ky.
44. Diamond Alkali—Houston, Texas

"Chlorinated hydrocarbons should continue to grow despite annual predictions that production of individual products will drop off due to market saturation because new uses continue to appear which more than compensate for losses due to outdated uses"

duction capacity of the Gulf Coast vs. time and the production capacity of the United States less the Gulf Coast production vs. time.

The 1970 point of all these curves are dotted showing what could happen in the way of annual plant capacity in 1970 and showing what has already been announced in the way of increased capacities for 1970. The lower dotted lines include Columbia Southern's 100 million-pound-per-year ethylene dichloride plant in the Lake Charles, Louisiana area; it includes Monochem's, a company jointly owned by U.S. Rubber and Borden, announced plans for a 150 million-pound-per-year vinyl chloride installation to be located in the Gulf Coast area; it includes Olin Mathieson's new glycerine plant at Doe Run, Ky. Another expansion announced last summer is Diamond Alkali's multi-million-dollar expansion in Deer Park, Texas, to manufacture the acetylene requirements from natural gas and increase their vinyl chloride from 50 to 75 million pounds per year.

Figure 1 shows total chlorinated hydrocarbon production and individual compounds. The uses for these individual products have varied over the years by a very wide range. Some products, such as carbon tetrachloride and chloroform, whose major uses today are raw materials for the production of fluorinated compounds, were introduced originally as cleaning fluids, dry cleaners, pharmaceuticals, etc. Other products, such as ethyl chloride, have a questionable future, because of the advent of tetramethyllead as antiknock fluid in gasolines and because technology has introduced a new method using organic-aluminums as a new route to the much-used lead compound. In this process chlorinated hydrocarbons are used, but only as intermediates, and only small fractions are required as compared to the old method of using the ethyl chloride as the ethyl radical in tetraethyllead.

Despite annual predictions that production of these individual products will drop off, because of market saturation, and so forth, notice that ethyl chloride is the only one of these products through 1959 which shows a definite downtrend. It is very evident that the curve for the older products has a flatter slope than the curve of those products introduced in the 1930s and 1940s. To date, however, new uses for each of these chlorinated hydrocarbon products appear requiring a higher production rate than the loss in production rate because of outdated uses. Although World War II occurred during the period shown in Figure 1, and also the Korean conflict when special tax concessions were issued for the manufacture of these products, neither of these events is obvious in the production patterns of chlorinated hydrocarbons.

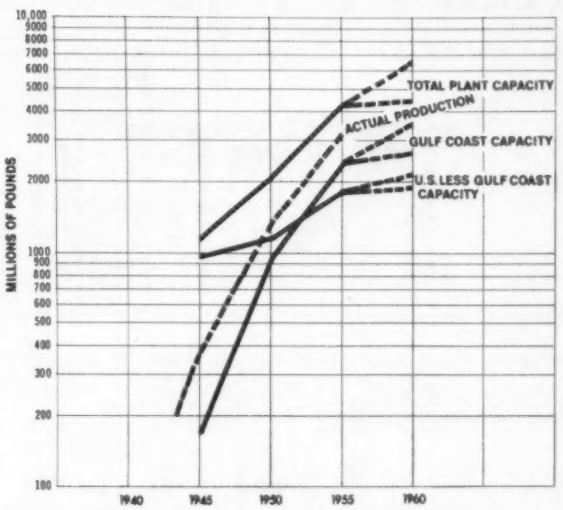

FIGURE 7—Shows a summation of production capacities for chlorinated hydrocarbons including some plants in standby condition and others not operating at design capacity. This is reflected by the actual production curve. Notice also the rapid growth of Gulf Coast production. Dotted lines show prediction of growth trends.

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Treichler

Originally presented before the AIChE, New Orleans, February, 1961.

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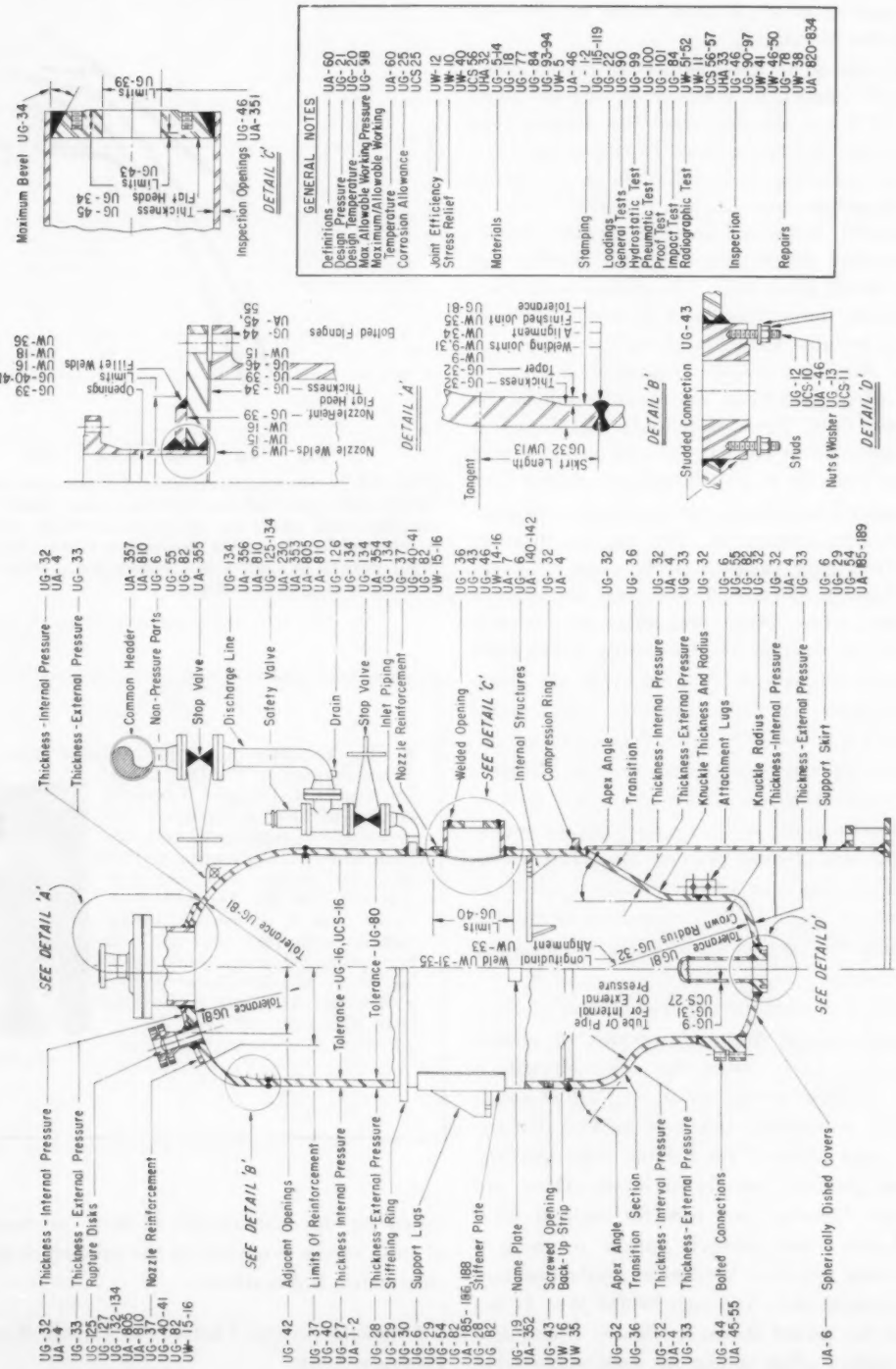
Revised Guide to ASME Vessel Code

Here's a graphical index to 1959 ASME Boiler and Pressure Vessel Code, Section 8. To use the guide, refer to the drawing for the part of interest and note appropriate code reference.

J. A. Hunter, Union Carbide Chemicals Company, Texas City, Texas



Nomographs Speed Vessel Design

Quick solutions are offered to common ASME pressure vessel design formulas

F. Caplan
Kaiser Engineers, Oakland, Calif.

NOMOGRAPHS can be used to give the designer quick solutions to the more commonly used design formulas in the 1959 ASME Boiler and Pressure Vessel Code, Section VIII.

In all these formulas, the term SE appears. SE is the product of the joint efficiency (see Figure 1) and the maximum allowable tensile stress value, selected from the Code, for the material and temperature used in design. Figure 1 gives a graphical solution for SE.

Example 1. What is SE for a vessel fabricated from 1 Cr. — ½ Mo. low alloy steel (design temperature 750°F, S = 15,000 psi) with single-welded butt joints and backing strips (E = 0.90)?

Align S = 15,000 with E = 0.90, Figure 1, and read SE = 13,500 psi?

THICKNESS OF CYLINDRICAL SHELLS

$$t = \frac{[P\,R]}{SE - 0.6\,P} = \frac{[P\,D]}{2\,(SE - 0.6\,P)}$$

Where t = minimum required shell thickness, exclusive of corrosion allowance

P = design pressure, psig

R or D = inside radius or diameter, before corrosion allowance, inches.

Example 2. What wall thickness is required for a 113 inch diameter vessel with 475 psig internal pressure, if S E = 20,000 psi?

Align S E = 20,000 with P = 475, Figure 2, and mark the intersection on pivot line. Align pivot line intersection with D = 113 and read t = 1.36 inches.

Example 3. What is the maximum allowable working pressure for an existing 120 inch diameter vessel with 0.500 inch walls if SE = 17,000?

Align D = 120 with t = 0.500, Figure 2, and mark the pivot line. Align SE = 17,000 with the pivot line and read P = 141 psig.

THICKNESS OF SPHERICAL SHELLS

$$t = \frac{[P\,R]}{2\,(SE - 0.1\,P)} = \frac{[P\,D]}{4\,(SE - 0.1\,P)}$$

Example 4. What is the maximum allowable working pressure of a sphere whose inside diameter is 40 feet (D = 480 inches), t = 2.00 and SE = 13,200?

Note: In this, and the other nomographs, the value of t is directly proportional to the value of D in accordance with the defining equations; therefore, if the nomograph scale value of D is multiplied by any number, then the scale value of t must be multiplied by the same number.

Align D = 48.0 = (0.1) (480) with t = 0.200 = (0.1) (2.00), Figure 3, and mark the pivot line intersection. Align pivot line with SE = 13,200 and read P = 220 psig.

THICKNESS OF ELLIPSOIDAL OR HEMISPHERICAL HEADS

For ellipsoidal heads, $t = \frac{[P\,D]}{2\,(SE - 0.1\,P)}$

For hemispherical heads, $t = \frac{[P\,L]}{2\,(SE - 0.1\,P)}$

Where L = inside spherical or crown radius, inches

Example 5. What shell thickness is required for L = 72 inches, S E = 20,000, and P = 950 psig?

Align S E = 20,000 with P = 950, Figure 4, and mark the pivot line.

Align L = 72 with the pivot line and read t = 1.72 in.

THICKNESS OF TORISPHERICAL HEADS

$$t = \frac{0.885\,P\,L}{SE - 0.1\,P}$$

Example 6. What head thickness is required for L = 55.0, SE = 19,600, and P = 1000 psig?

Align SE = 19,600 with P = 1000, Figure 5, and mark the pivot line. Align L = 55 with the pivot line and read t = 2.5 in.

Figures continued on following page .

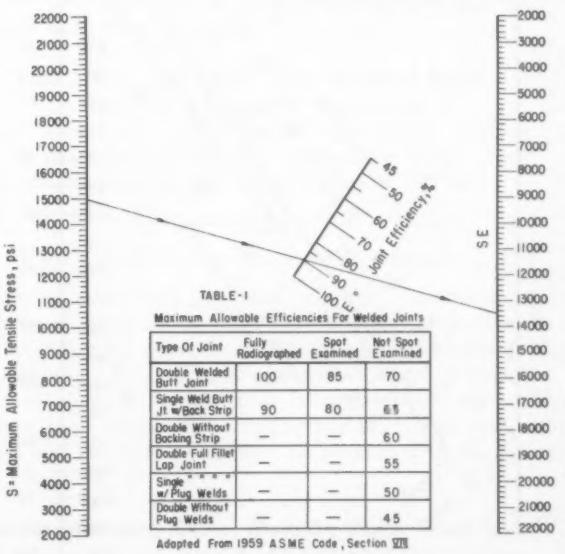


TABLE-1
Maximum Allowable Efficiencies For Welded Joints

Type Of Joint	Fully Radiographed	Spot Examined	Not Spot Examined
Double Welded Butt Joint	100	85	70
Single Weld Butt Jt w/Back Strip	90	80	65
Double Without Backing Strip	—	—	60
Double Full Fillet Lap Joint	—	—	55
Single w/ Plug Welds	—	—	50
Double Without Plug Welds	—	—	45

Adapted From 1959 ASME Code, Section VIII

FIGURE 1

Nomographs Speed Vessel Design . . .

Thickness Of Cylindrical Shells

$t = \frac{PD}{2(SE-0.6P)}$ Key: SE — P — Pivot Line; Pivot Line — t — D

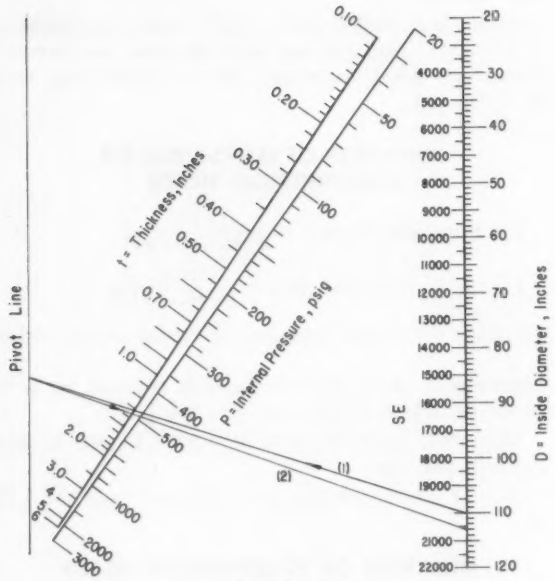


FIGURE 2

Thickness Of Spherical Shells

$t = \frac{PD}{4(SE-0.1P)}$ Key: SE — P — Pivot Line; Pivot Line — t — D

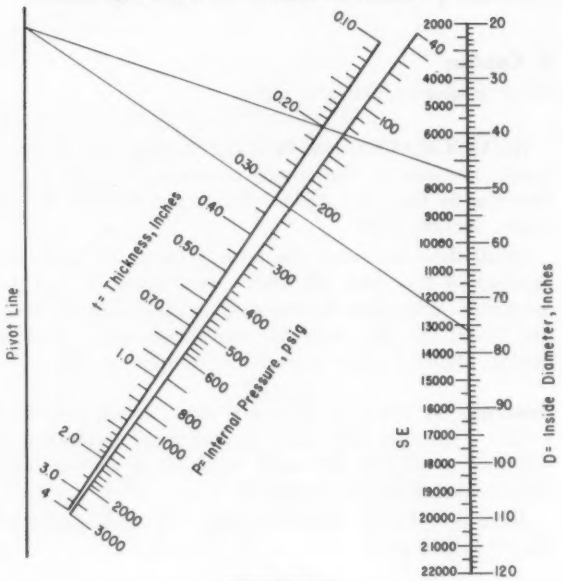


FIGURE 3

Thickness Of Ellipsoidal Or Hemispherical Heads

Key: SE — P — Pivot Line; Pivot Line — t — D, L

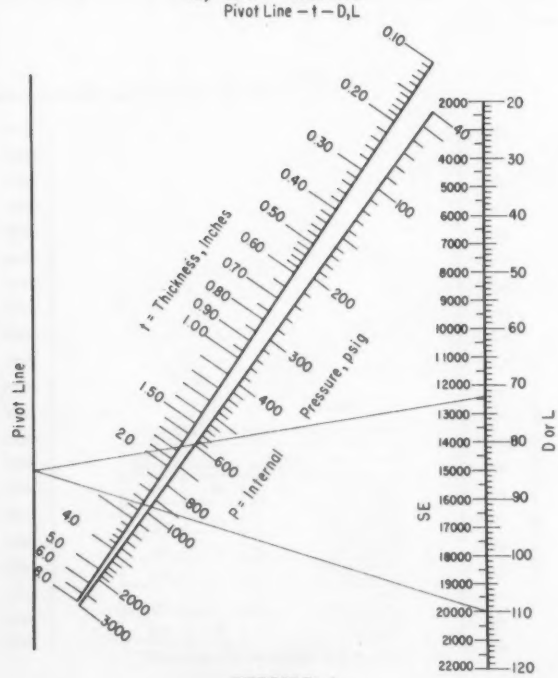


FIGURE 4

Thickness Of Torispherical Heads

$t = \frac{0.885\,PL}{SE-0.1P}$ Key: SE — P — Pivot Line; Pivot Line — t — L

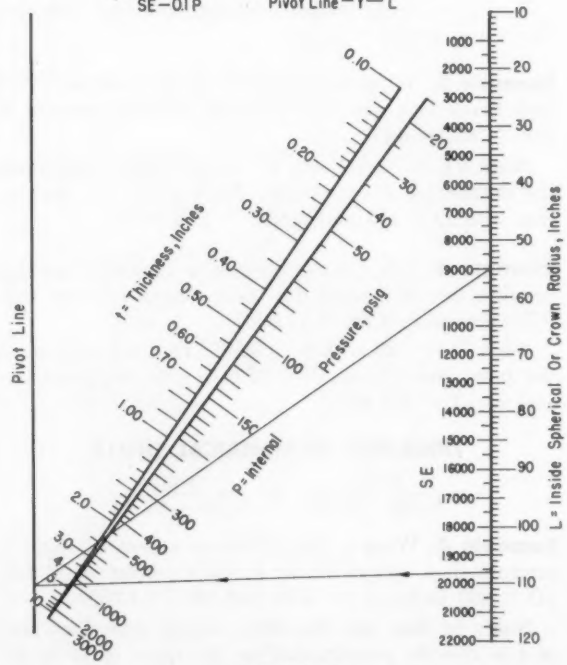


FIGURE 5

Find Equilibrium Constants Graphically

These nomograms permit rapid thermodynamic screening of exploratory reactions, estimation of a desired conversion temperature, and extrapolation of phase equilibrium constants with temperature

Edward A. Destremps, Ivan Mayer and Peter L. Silveston, Esso Research and Engineering Company, Linden, N. J.

THIS ARTICLE presents a rapid method for estimating equilibrium constants. Nomograms have been developed which relate the chemical equilibrium constant at any temperature to the heat and free energy changes for the reaction in the standard state at 298° K. The nomograms can be used to check the thermodynamic feasibility of a reaction, or to determine the temperature required for a certain conversion. They can also be used to estimate the change of phase equilibrium constants with temperature. Examples illustrate their use.

DERIVATION OF NOMOGRAMS

For the reaction, $bB + cC \rightleftarrows dD$, the equilibrium constant, K, is defined by the following equation:

$$\Delta F^\circ = -RT \ln \frac{(a_D)^d}{(a_B)^b (a_C)^c} = -RT \ln K \qquad (1)$$

where ΔF° is the free energy change for the reaction in the standard state, and a is the activity of the products and reactants at equilibrium.

The change of K with temperature is given by the van't Hoff equation:

$$\frac{d(\ln K)}{dT} = \frac{\Delta H^\circ}{RT^2} \qquad (2)$$

where ΔH° is the heat of reaction in the standard state.* For many chemical reactions, ΔH° varies little with temperature and can be taken as a constant without appreciable error. This is the only assumption necessary. It is a good one as will be shown later. ΔH° at 298° K (537° Rankine) is used since most thermodynamic tables give values at that temperature. Integrating Equation (2) between 537° Rankine and T, and combining with Equation (1) gives

$$2.303 \log K = -\frac{\Delta H^\circ_{298}}{RT} + \frac{(\Delta H^\circ - \Delta F^\circ)_{298}}{537\,R} \qquad (3)$$

Equation (3) gives the chemical equilibrium constant at any temperature in terms of the heat and free energy changes for the reaction in the standard state at 298° K. The nomograms on Figures 1 and 2 are based on this equation.

Before discussing use of the nomograms, a brief review of the procedure for calculating ΔH°_{298} and ΔF°_{298}, and of units may be helpful.

Find ΔH°_{298} And ΔF°_{298} From Standard Heats And Free Energies Of Formation

ΔH°_{298} and ΔF°_{298} are readily calculated by summing up the heats and free energies of formation of the products and reactants in the standard state at 298° K.

$$\Delta H^\circ_{298} = \Sigma \Delta H^\circ_f \text{ Products} - \Sigma \Delta H^\circ_f \text{ Reactants} \qquad (4)$$

$$\Delta F^\circ_{298} = \Sigma \Delta F^\circ_f \text{ Products} - \Sigma \Delta F^\circ_f \text{ Reactants} \qquad (5)$$

Tables of ΔH°_f and ΔF°_f for the more common compounds are given in many sources.[1,2,3,4] Several methods are available for approximating values for unlisted compounds.[5] If ΔH°_f and ΔF°_f are obtained from several sources, check to be sure that the standard states (the datum level above which ΔH°_f and ΔF°_f are evaluated) are consistently defined. References 1 through 5 are consistent.

Correct Standard States Must Be Used. When finding ΔF°_{298} for the reaction A(liq.) $\rightleftarrows$ B(liq.), values of ΔF°_f (gas) cannot be used, and vice versa. Liquid

* The standard states used in this article are the same as those used in References 1 through 5.

Find Equilibrium Constants Graphically...

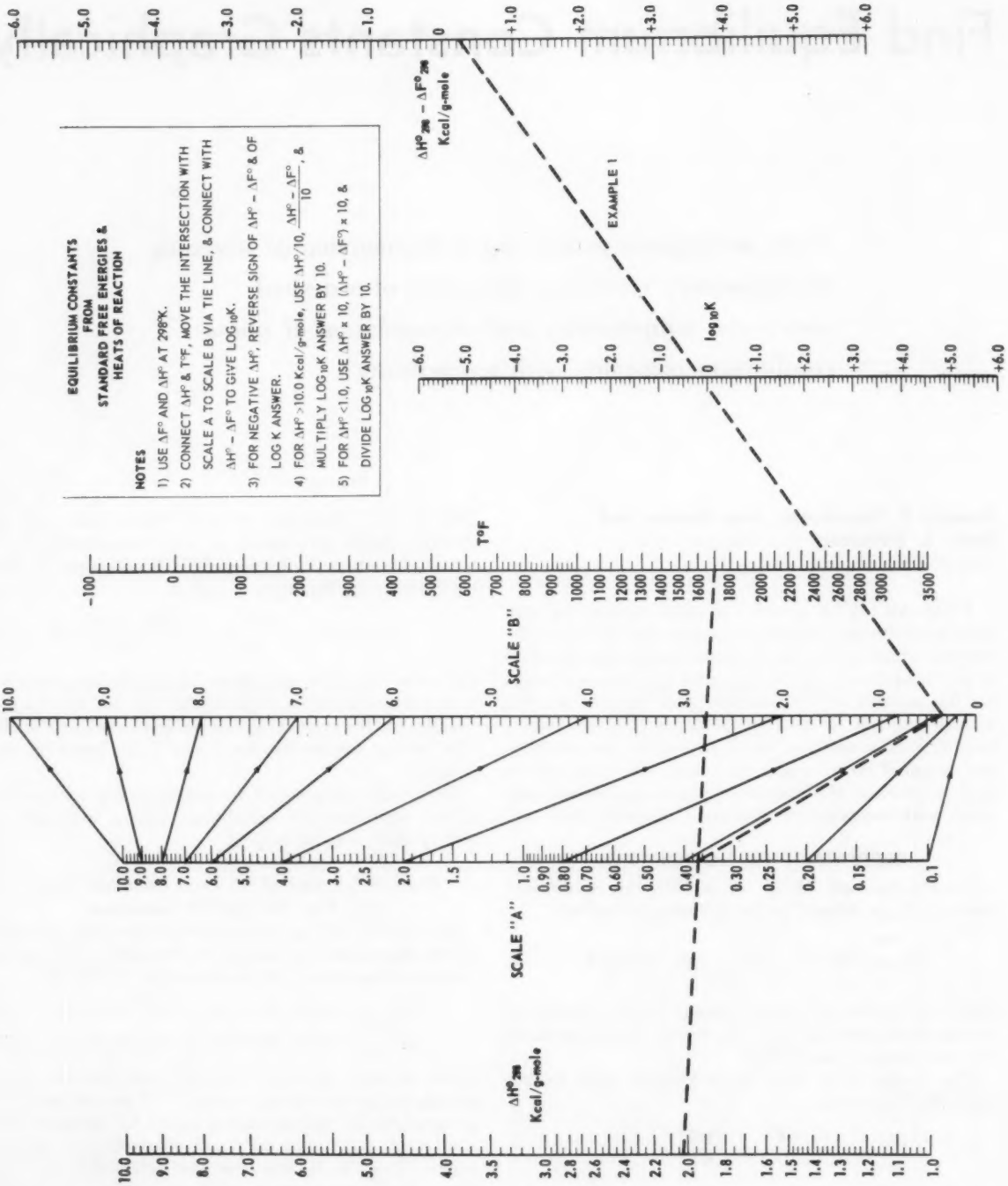

EQUILIBRIUM CONSTANTS
FROM
STANDARD FREE ENERGIES &
HEATS OF REACTION
NOTES
1) USE ΔF° AND ΔH° AT 298°K.
2) CONNECT ΔH° & T°F, MOVE THE INTERSECTION WITH SCALE A TO SCALE B VIA TIE LINE, & CONNECT WITH ΔH° − ΔF° TO GIVE LOG₁₀K.
3) FOR NEGATIVE ΔH°, REVERSE SIGN OF ΔH° − ΔF° & OF LOG K ANSWER.
4) FOR ΔH° >10.0 Kcal/g-mole, USE ΔH°/10, (ΔH° − ΔF°)/10, & MULTIPLY LOG₁₀K ANSWER BY 10.
5) FOR ΔH° <1.0, USE ΔH° x 10, (ΔH° − ΔF°) x 10, & DIVIDE LOG₁₀K ANSWER BY 10.
ΔH°298 − ΔF°298 Kcal/g-mole
EXAMPLE 1
log₁₀K
T°F
SCALE "B"
SCALE "A"
ΔH°298 Kcal/g-mole

FIGURE 1—Is designed for finding log K at any single temperature as shown in Example 1.

values may be calculated from gaseous values by finding the change in $\Delta H°_f$ and $\Delta F°_f$ for the following three operations at 298° K:

a. Expand the gas from unit fugacity, which is usually 1.0 atm, to the vapor pressure of the pure liquid at 298° K, P.

b. Condense the gas at P.

c. Compress the liquid from P to 1 atm.

The effect of step c is usually negligible and, thus, for an ideal gas

$$\Delta H°_f(\text{liq.}) = \Delta H°_f(\text{gas}) + \text{heat of condensation} \quad (6)$$

$$\Delta F°_f(\text{liq.}) = \Delta F°_f(\text{gas}) + RT \ln P. \quad (7)$$

Equilibrium Constants Are Dimensionless. Since K is a ratio of activities which are dimensionless, K must by definition be dimensionless. However, when calculating yields or conversions, activities are usually expressed as partial pressures or concentrations. In such cases dimensions become important.

The following dimensions should be used: The activity of an ideal gas is numerically equal to its partial pressure in atmospheres. The activity of a real gas at low pressure is approximately equal to its partial pressure in atmospheres. Fugacities should be used at high pressure.

The activity of a component in an ideal nonaqueous solution is its concentration, expressed as mole fraction. The activity of a solute in dilute aqueous solution may be taken as its molality (moles per 1000 gms. water).

The activity of a pure solid or liquid may be taken as unity, except at very high pressure.

Figure 1 Gives Log K At Any Single Temperature

Once $\Delta H°_{298}$ and $\Delta F°_{298}$ are known, the equilibrium constant is quickly found from either Figure 1 or 2. Figure 1 is designed for finding log K at any single temperature, as shown by the following example.

Example 1—Estimate the degree of dissociation of H_2S at 1700° F and 1.0 atm.

$$H_2S(\text{gas}) = H_2(\text{gas}) + \tfrac{1}{2}S_2(\text{gas})$$

Solution—From Reference 1, the following data are available at 298° K:

	$\Delta H_f°$ K-Cal/mole	$\Delta F_f°$ K-Cal/mole
H_2S(gas)	—4.77	—7.85
H_2(gas)	0	0
S_2(gas)	31.02	19.36

Using Equations (4) and (5)

$$\Delta H°_{298} = \tfrac{1}{2}(31.02) - (-4.77) = 20.28$$

$$\Delta F°_{298} = \tfrac{1}{2}(19.36) - (-7.85) = 17.53$$

By subtraction, $(\Delta H° - \Delta F°)_{298} = 2.75$ K-Cal/mole H_2S. Since $\Delta H°_{298}$ is off the scale of the nomogram, $\Delta H°_{298}$ and $(\Delta H° - \Delta F°)_{298}$ are divided by 10 (or any other suitable number) and the answer multiplied by 10 (or any other suitable number). As shown on Figure 1, $\Delta H°/10$ is connected with T°F to give 0.37 on scale A. The tieline gives the same value on scale B. This point is connected to $(\Delta H° - \Delta F°)/10$ to give log K/10 = —0.17. Thus, log K = —0.17 × 10 = —1.7, and K = 0.02.

Since the pressure is low, partial pressures may be used for activities and, thus,

$$K = \frac{p_{H_2}\, p_{S_2}{}^{1/2}}{p_{H_2S}} = \frac{D^{1.5}\pi^{0.5}}{(1-D)(2+D)^{0.5}} \quad (8)$$

where D is the dissociation of H_2S and π is the total pressure. Substituting 0.02 for K, and 1.0 atm for π, the dissociation of H_2S is calculated to be 8.9 percent.

Figure 2 Gives Log K As Function Of Temperature

Figure 2 can be used to find single temperature values of K, as well as the variation of K with temperature. It is actually a plot of log K (outside scale at the left) vs. 1/T°R (bottom scale). This is a straight line according to Equation (3). For simplicity, the temperature scale is calibrated in °F.

One point on the equilibrium line is $\Delta F°_{298}$ on the vertical scale at 77° F, and the other is $(\Delta H° - \Delta F°)_{298}$ on the inside scale at the left where T is infinite, that is, where 1/T = 0.

The temperature needed to make a reaction go appreciably is that where log K becomes greater than zero.

Example 2—Find the temperature needed for 90 percent dissociation of H_2S to H_2 and S_2 (gas).

Solution—Substituting 0.9 for D in Equation 8, log K is determined to be 0.7. Using the values calculated in Example 1, a straight line is drawn on Figure 2 between $\Delta F°_{298} = 17.53$ and $(\Delta H° - \Delta F°)_{298} = 2.75$. The intersection of this line with log K = 0.7 occurs at about 4,000° F. This is the required temperature.

If the scales on Figure 2 are too large or too small for a particular reaction, $\Delta F°_{298}$ and $(\Delta H° - \Delta F°)_{298}$ may be multiplied or divided by any suitable factor. Reverse the operation on log K to get the correct answer. For example, assume the values are 1.0 and 0.5 K-Cal/mole respectively, and log K is desired at 3000° F. Multiply each value by, say 20, plot the straight line, and read log K as 4.0 Then divide by 20 to get the answer which is 0.2.

$\Delta F°$ and $\Delta H°$ Can Be Estimated From Equilibrium Constants

Figure 2 may be used to estimate $\Delta H°$ and $\Delta F°$ from experimentally determined equilibrium constants. The experimental constants are plotted against T°F and the best straight line drawn through the points. The intersection of this line with the vertical scale at 77° F gives

$\Delta F°_{298}$. The intersection with the inside scale at the left gives $(\Delta H° - \Delta F°)_{298}$, from which $\Delta H°$ may be found by addition. $\Delta F°$ may be found at temperatures other than 77° F by multiplying log K at the desired temperature by —2.303 RT.

If only one experimental point is available, the equilibrium line can be plotted if $\Delta H°$ is known since the slope is $-\Delta H°/2.303$ R. When laying off the slope, use temperature units of 1/T° Rankine. Perhaps the easiest way of finding the slope is to draw a straight line between the point log K = 0 at T equals infinity, and the value of $\Delta H°_{298}$ on the $\Delta F°_{298}$ scale at 77° F. This line has the same slope as the equilibrium line because when the intercept of Equation (3) (second term on right hand side) is zero, $\Delta H°_{298} = \Delta F°_{298}$. A straight line drawn parallel to this line through the experimental point gives the desired equilibrium line.

Assumption of Constant $\Delta H°$ Is Good. As discussed previously, $\Delta H°$ was assumed to be constant in order to integrate the van't Hoff equation. This assumption is rigorous for reactions between ideal gases where there is no change in moles. It is sufficiently accurate for most real reactions even when there is a change in moles, as illustrated by Table 1. The change in heat of reaction over the entire 1083° F temperature range is only 7.0 percent, 12.8 percent, and 5.2 percent respectively. The smallest change for these reactions actually occurs where there is an increase in moles.

TABLE 1—$\Delta H°$ changes little with temperature

REACTION	$\Delta H°$, K-Cal/g-Mole[2]		
	77° F	620° F	1160° F
1. n Butane $\rightleftarrows$ Methyl Propane	—2.00	—1.94	—1.86
2. $CO + H_2O \rightleftarrows CO_2 + H_2$	—9.84	—9.30	—8.58
3. $C_2H_6 \rightleftarrows H_2 + C_2H_4$	32.73	33.88	34.42

Equilibrium constants for the reactions in Table 1 were estimated by use of Figure 2. They are compared with rigorous values in Figure 3. The latter were calculated by taking into account the variation of $\Delta H°$ with temperature, using data obtained from Reference 2. The rigorous values, shown by the points, are very close to the straight line prediction. This is especially true in the low temperature range since the straight lines are anchored theoretically at 77° F. Comparable accuracy has been found for many other reactions.

Thus, in the absence of data showing how $\Delta H°$ varies with temperature, Figure 1 or 2 can be used to estimate chemical equilibrium constants accurately enough for exploratory work or first approximations.

Application To Phase Equilibria. Just as the chemical equilibrium constant is defined as a ratio of activities, so can the phase equilibrium constant be defined as the ratio of the activity of a substance in one phase to its activity in another. As a result of this similarity, Equation (2) and Figure 2 can also be used to estimate the change of phase equilibrium constants with temperature. Heat of transition (ΔH) is used in place of heat of reaction, it being defined as the net heat effect on transporting one mole of a substance from one phase to the other.

If ΔH is known, the slope of the equilibrium line, which is $-\Delta H/2.303$ R, may be found by drawing a straight line on Figure 2 between the point log K = 0 at T = ∞, and ΔH on the $\Delta F°_{298}$ scale at 77° F. Be careful to use the proper sign, exothermic heat being negative. Knowing the slope, only one data point is needed to plot the equilibrium line.

Table 2 lists some of the equilibrium constants which plot as approximate straight lines on Figure 2. This list is by no means complete. Note that substitution of the first item of Table 2 in Equation 2 gives the familiar Clausius-Clapeyron equation.

TABLE 2—These equilibrium constants plot as approximate straight lines on Figure 2.

EQUILIBRIUM	Equilibrium Constant	Heat of Transition K-Cal/g-Mole
Vapor-Liquid	P	Vaporization
	f	Vaporization
	H	Dissolution
Liquid-Liquid	C	Dissolution
	B	Dissolution
Vapor-Solid	P	Isosteric Desorption
	P	Sublimation
Liquid-Solid	C	Dissolution

Figure 2 must be used with caution when extrapolating phase equilibrium data because heat of transition usually changes appreciably with temperature. This is in contrast with the almost constant heat of reaction in chemical equilibrium. Since heat of vaporization rapidly goes to zero as the critical point is approached, Figure 2 should not be used in this region.

Example 3—The heat of vaporization of pure water at its normal boiling point (1.0 atm, 212° F) is 9.7 K-Cal/g-mole. Estimate the vapor pressure of water at 400° F.

Solution—A straight line is drawn on Figure 2 between the point log K = 0 at T = ∞, and the point $\Delta H = 9.7 \times 4 = 38.8$ at 77° F. The factor of 4 is used for greater accuracy. The equilibrium line is drawn parallel to this line through the point log K = 0 at 212° F. At 400° F, log K = 5/4 = 1.25 or K = 17.8 atm. The true value is 16.8 atm, which is only 5.6 percent less.

For solutions of solids in liquids which approach ideality, solubility curves may be drawn up in the same manner as the vapor pressure curve in Example 3. The slope is determined by the points log K = 0 at T = ∞, and the heat of fusion of the solid on the $\Delta F°_{298}$ scale at 77° F. The solubility curve is drawn with this slope

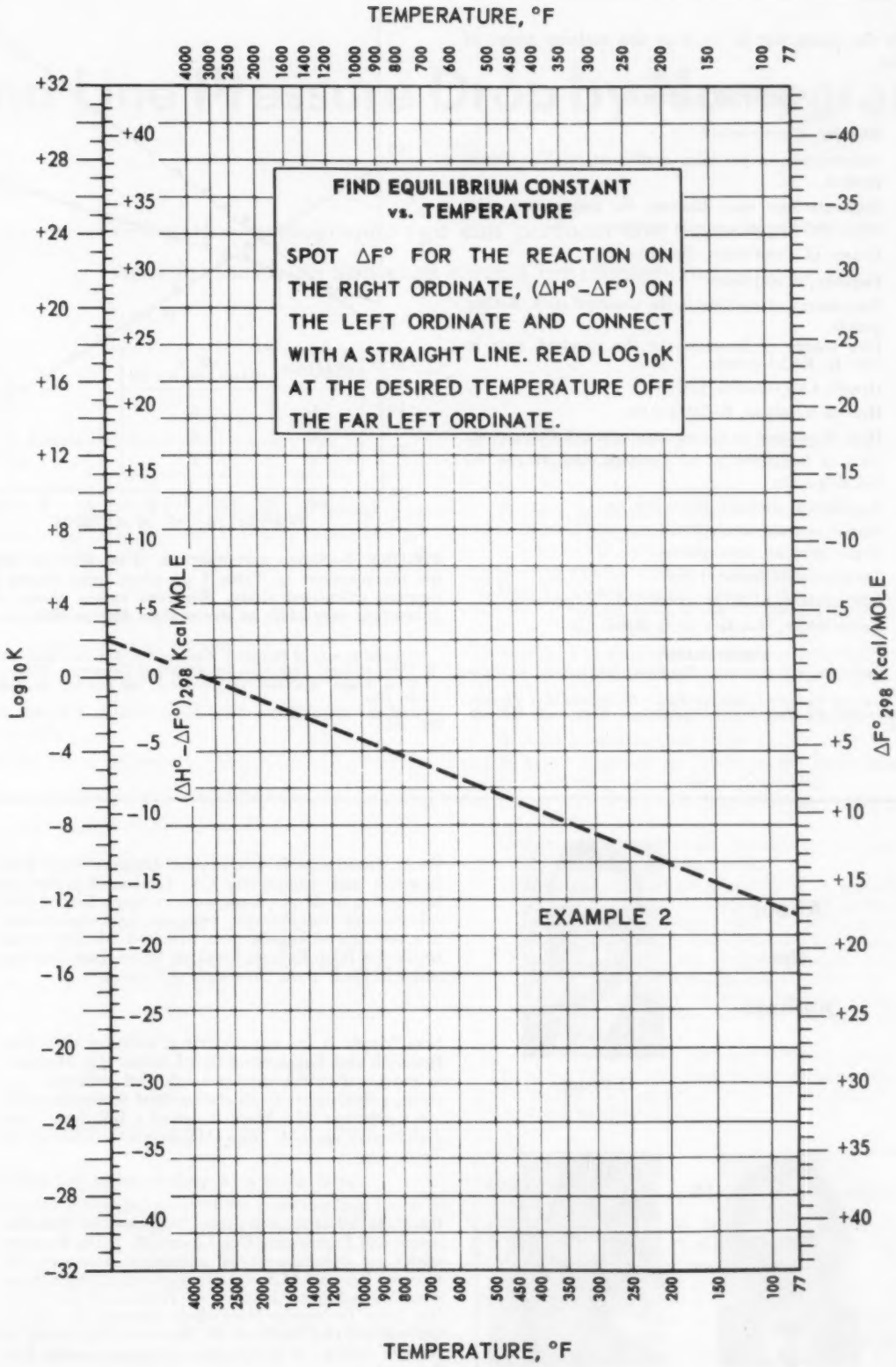


FIGURE 2—Can be used to find single temperature values of K as well as the variation of K with temperature.

through the point log K = 0 at the melting point of the solid.

NOMENCLATURE

a	Activity, dimensionless.
B	Distribution or partition coefficient, C_1/C_2, dimensionless.
C	Concentration; mole fraction for nonaqueous solutions, molality for aqueous solutions.
D	Degree of dissociation, dimensionless.
f	Fugacity, atmospheres.
$\Delta F°$	Free energy of reaction in the standard state, K-Cal/g-mole.
$\Delta F°_f$	Free energy of formation in the standard state at 298° K, K-Cal/g-mole.
H	Henry's Law constant, p/C.
ΔH	Heat of transition, K-Cal/g-mole.
$\Delta H°$	Heat of reaction in the standard state, K-Cal/g-mole.
$\Delta H°_f$	Heat of formation in the standard state at 298° K, K-Cal/g-mole.
K	Equilibrium constant, dimensionless.
p	Partial pressure, atmospheres.
P	Vapor pressure, atmospheres.
π	Total pressure, atmospheres.
R	Gas constant, 1.104×10^{-3} K-Cal/°R/g-mole.
T	Temperature, °Rankine or as noted.

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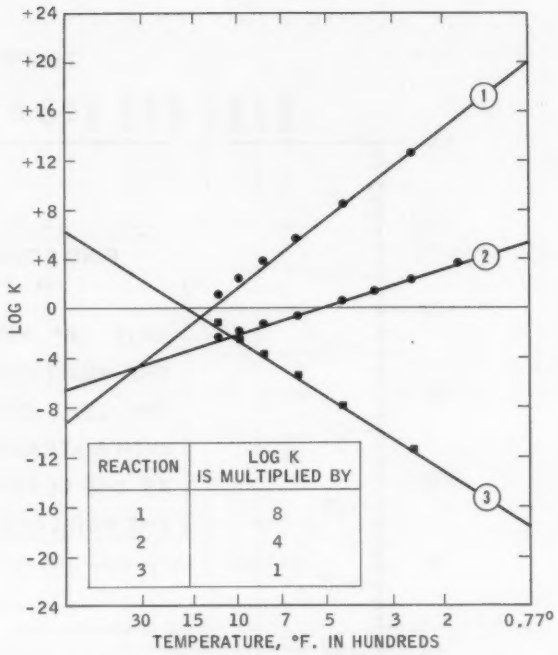

FIGURE 3—Shows a comparison of equilibrium constants for the reactions in Table 1 as taken from Figure 2 and rigorous calculated values. Rigorous values, shown by the points, are very close to the straight line prediction.

About the Authors

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Find Line Pressure Drop by Nomograph

Using this nomograph, you can perform five important steps in line sizing and even correct for changes in friction factor

John D. Lewis, Hydrocarbon Research, Inc.
New York City

HERE'S A NEW TYPE of nomograph for sizing lines and estimating pressure drop. It is easy to use and gives rapid results of sufficient accuracy for ordinary line sizing problems.

Using this nomograph you can find the following:

- The pressure drop in a given line
- The line size giving a desired pressure drop
- The line size giving "economic" pressure drop (for gases only)
- Correct for a different friction factor
- The pressure drop in a new line size
- The allowable flow in a given line.

This nomograph solves the Fanning equation expressed in the form:

$$\Delta p/100\ \text{ft} = \frac{f}{74{,}000} \frac{W^2}{\rho d^5}$$

where Δp = pressure drop, psi per 100 ft of pipe
W = flow, pounds per hour
ρ = fluid density, lbs/ft^3
d = inside diameter, inches
f = friction factor, assumed equal to 0.004. The chart can be corrected for other friction factors as described below.

and can be used as follows:

1. To find the pressure drop in a given line:

A. Locate a working point on the reference line, by laying a straight edge from the density scale to the flow scale.
B. Move horizontally from the working point until the diagonal line showing the correct line size is intersected.
C. Read the pressure drop.

2. To find the line size giving a desired pressure drop:

A. Find a working point as in 1.
B. Move horizontally from the working point until the vertical line showing the desired pressure drop is intersected.
C. Read the line size on the diagonal scale.

3. To find the line size giving "economic" pressure drop (for gases only):

A. Find a working point as in 1.
B. Move horizontally from the working point until a vertical line extended up from the pressure scale is intersected.
C. Read the line size on the diagonal scale.

Note 1: The "economic" pressure drop is based on a correlation given in the PETROLEUM REFINER, Vol. 3, No. 7, Page 151 (1951).

Note 2: The pressure scale does not necessarily show the actual pressure except at the economic size.

4. To correct for a different friction factor:

A. Find a working point as in 1.
B. Move diagonally to 100 times the new friction factor as shown on the pressure drop scale.
(**Note:** This is the only time a diagonal move should be made.)
C. Move horizontally back to the reference line to find the corrected working point.
D. Continue with Steps B and C as in paragraph 1, 2 and 3. For example, suppose we had 1,000 lbs/hr of material with a density of 0.12 lbs/ft,^{3} and our preliminary work had shown that a 2.7 inch dia line was required to give the desired pressure drop of 0.3 psi/100 ft. We decided to use a 3 inch line. A more careful check later on shows that the actual friction factor is 0.006 instead of 0.004. We make the correction as follows:
A. Start where the 2.7 inch line intersects the 0.3 psi line.
B. Move horizontally back to the reference line to find the old working point, then move diagonally to the 0.6 psi vertical line.

Lewis

About the Author

John D. Lewis is a project engineer for Hydrocarbon Research, Inc., and supervises the design of petrochemical plants in this country and abroad. Mr. Lewis started with HRI in 1952 and before that was in the research department of Standard Oil Company of Indiana. Mr. Lewis received a B.S. in chemical engineering from Cornell University in 1948 and has studied at MIT and Manchester University.

Find Line Pressure Drop by Nomograph...

C. Move horizontally back to the reference line to find the corrected working point.

D. Move horizontally back to the 0.3 psi vertical line. The new required line size is seen to be 2.9 inches instead of 2.7 inches as estimated originally.

E. Instead of stopping at the 0.3 psi vertical line, we could continue moving horizontally past the 0.3 psi line to the 3 inch diagonal line. Here we can read that the actual pressure drop will be 0.27 psi/100 ft. in a 3 inch line.

5. To find the pressure drop in a new line size:

A. Find the point on the chart where the old line size intersects the existing pressure drop.

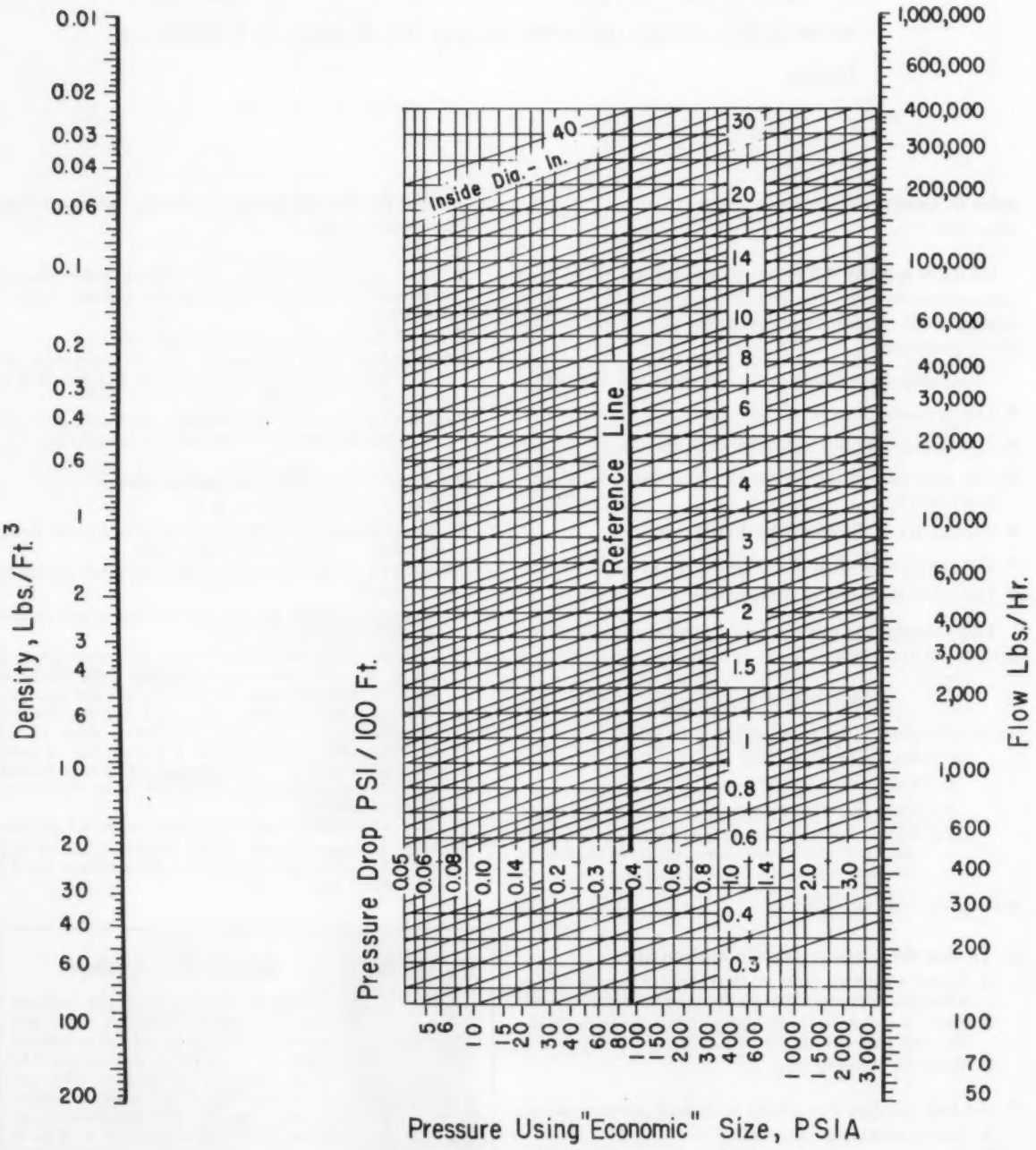
B. Move horizontally to the new line size and read the new pressure drop.

6. To find the allowable flow in a given line:

A. Use the given line size and the allowable pressure drop to find a point on the chart.

B. Move horizontally to the reference line to find a working point.

C. Lay a straight edge from the density scale through the working point to find the allowable flow.



Instructions—1. Locate a working point on the reference line by laying a straight edge from the density scale to the flow scale. 2. Move horizontally to the desired pressure drop or the desired line size, or to the operating pressure to find the "economic" size. Note: Chart is based on a friction factor of 0.004.

How to Evaluate Chemical Projects

Here is a method, complete with example, for selecting the best project. The importance of considering all costs and revenues and their timing is completely illustrated

H. C. Thorne, Jr., W. W. Twaddle and E. R. Grahl,
Amoco Chemicals Corporation, Chicago

SOUND APPRAISAL of the economics of any new project in any business requires that every element of revenue and expense be considered. In some industries, all project alternates may be similar in character, making possible a fairly simple approach to the problem.

In the chemical business, projects with widely differing characteristics must be compared. Hence it is particularly important that:

1. All costs and revenues be considered;

2. The evaluation technique recognize the timing of these items.

DIFFERENT CHEMICAL PRODUCTS HAVE DIFFERENT CHARACTERISTICS

Some examples of the major areas in which chemical projects can differ are:

Market: Are there existing markets for this product or must they be developed?

Are the projected volumes and growth rates large or small?

Are the selling expenses and customer service requirements big or small?

Where is the market? Does the price include delivery?

How severe is competition?

Product: Are customer specifications easy to meet?

How do the physical and chemical properties affect processing, handling and shipping?

Process: Is the process new, or existing?

Is it simple or complicated?

Is it batch or continuous?

Is much development work required?

Economic: How sensitive is the project to changes in such things as selling price, or investment?

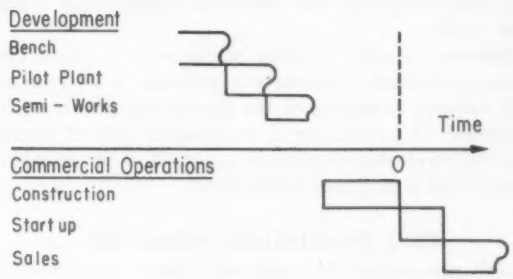
What is the likelihood of government assistance (or restrictions)?

What is the business cycle influence?

General Fit: What is the company's current position and know-how in this field?

The answers to these and similar questions determine the costs and revenues of any project. It is obvious that wide differences between projects are possible.

Steps in Commercial Chemicals Development



Several economic evaluations are normally required during the development of any successful commercial chemical. They logically arise when a decision for a different order-of-magnitude of capital and effort is required. A schematic representation of these decision points is shown above. It is the typical "test tube to tankcar" sequence. First there is the **bench stage** of development. Here small quantities of the product are prepared and preliminary process, product and market research activities undertaken. If the product continues to look promising, **pilot plant** operations are justified. Larger quantities will be produced and test marketed. Process variable studies will be more complete, economic studies more accurate. Sometimes commercialization approval is possible after pilot plant development. Frequently, a **semi-works** is required either for (1) proving out certain novel aspects of commercial design which cannot be shown adequately in the pilot plant; or (2) supplying additional material for market development.

If development plans are successful and **commercialization** approved, a plant is constructed, and started up. Finally, 5, 10 or more years after initial research work, sales begin, frequently at far less than capacity operations. Then, as markets expand, and competition increases, gradual price reductions commonly occur.

To properly handle the various cost and revenue elements of a chemical project, the time value of money must be considered. The discounting technique for calculating a rate of return has many names, including discounted cash flow, interest rate of return, investors method, internal rate of return, and profitability index. This article will use the last, abbreviated to PI. The technique has been well described in the literature.[1,2,3] It is simply the rate of compound interest at which the company's outstanding investment in a project is repaid by the proceeds of the project.

Of course, no single number can answer all ques-

tions. Other economic criteria can supplement the PI estimate. For all of these, estimate reliability is most important; the effect of uncertainties and omissions on the profitability estimate must be considered. And there are certainly plenty of uncertainties whenever forecasts are made far into the future. This is particularly true during the early stages of a new development, when the available data are limited and of uncertain accuracy.

The ultimate goal—the investment decision itself—requires considerations beyond the scope of this article. The calculated rate of return must be compared with some standard, such as the company's cost of capital. Then the decision-makers, who may not even know the evaluator, weigh all the risks and benefits and render their verdict.

However, a good decision starts with a sound economic evaluation. This article provides a description, with suitable examples, of the many appraisal elements important in calculating a meaningful rate of return. The end result is a reasonable approach to the economic appraisal of a proposed investment.

TWO EVALUATION PRINCIPLES

Let's summarize two basic evaluation principles before reviewing the major cost elements of a typical project.

The **first principle** is that in any evaluation you are really choosing between mutually exclusive alternates, two at a time. The alternates may be different ways of running your proposed operation, different uses for a certain raw material or merely the comparison of the proposed project with continuing current operations. When you have several mutually exclusive projects under consideration, you in step-wise fashion eliminate the least desirable alternates until you end up with the best or most favorable alternate.

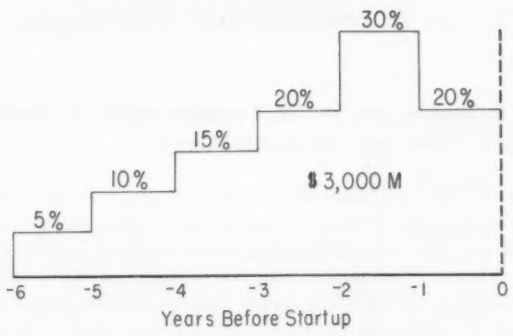
The **second evaluation principle** is that one considers all cash flows, after tax, **from today forward.** Money which is spent before "today" and cannot be recovered represents a sunk cost and should not be considered in the evaluation. In some instances, past investment can generate income "today" via liquidation. If existing equipment is utilized in a new process, it would be charged to the process at its highest alternate use value. Its minimum alternate use value would be the undepreciated balance on the tax books. The corresponding minimum after tax cash flow would be this value times the tax rate.

TIME, COST AND REVENUE ELEMENTS OF A TYPICAL NEW CHEMICAL PROJECT

Now, let's put some meat on the bones of this article by discussing a hypothetical new commercial chemical—Project X. To make things simple, the alternate which this project will be compared against will be the option of continuing as we were, i.e., constructing no new project.

We assume a 15-year project life, sum-of-the-years digits (SYD) depreciation on all depreciable investment and a 54 percent tax rate on all taxable income. The 54 percent U.S. tax rate is for a company including its subsidiaries in a consolidated tax return. A further simplification which may not apply generally is the recognition that the over-all company yields a profit. This allows recovery of a tax credit instantaneously against project losses, and avoids the issue of carry forward of losses.

Project X — Development Costs

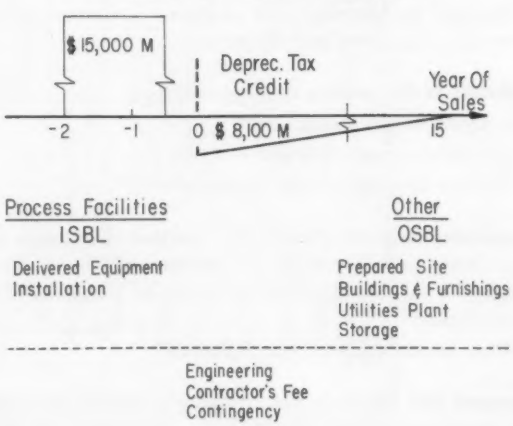


(Exploratory Research)
Process R&D
Product R&D

Market R&D
Patents & Licenses
Process Design & Economics

These future development costs are specific to the project, can be either capital or expense items, and occur prior to commercial sales. These costs are assumed to total $3 million and be spent over a six-year period. The expenditures follow a more or less typical pattern increasing to a maximum shortly before commercialization and dropping off thereafter. For the purpose of this example, we have considered all outlays as expense. Development costs include exploratory research, shown above in parentheses, since it normally is completed before any economic evaluations are made. The major future costs include process research and development, product research and development, market research and development, licensing efforts, and process design and economic studies.

Project X — Fixed Capital

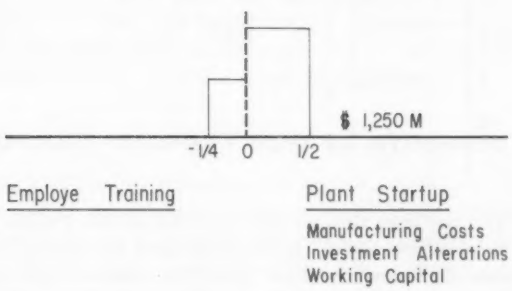


As development work approaches completion, a commercial plant will be built, assuming the project

still remains attractive. The first thing that is required is fixed capital to build the plant. Fixed capital can be considered the total original value of physical facilities which are not carried as current expense on the books of account and for which depreciation is allowed by the Federal Government. This includes plant equipment and all other costs incident to getting the property in place and in operating condition, including legal costs, purchased patents and paid up licenses. Land, which is not depreciable, is often included. For Project X an investment of $15 million is assumed, resulting in a plant of 25 million pounds per year capacity. A separate study is presumed to have shown this to be the preferred size. This investment is spent over a 1½-year period and for the sake of this example, is assumed to be spent uniformly. In actual practice, it is spent at a maximum rate near the middle of the construction period. Fifty-four percent of the investment is recovered over the life of the project as a deduction from federal income tax. The plant is assumed to have no salvage value.

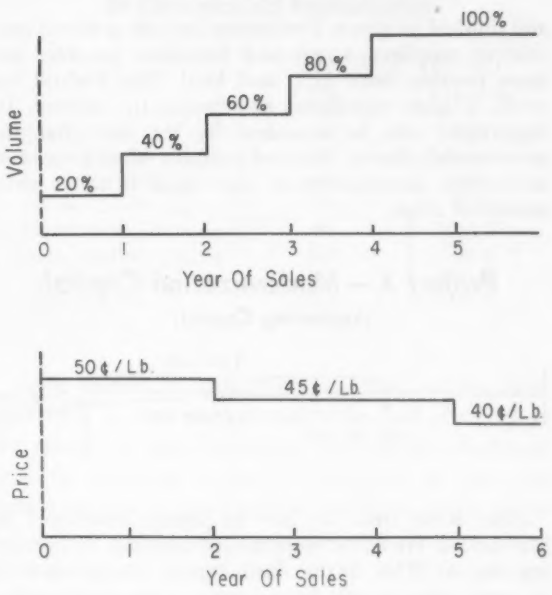
Use this as a checklist of some of the major components of fixed capital. Process facilities are those inside battery limits (ISBL). Included are the delivered cost of all major equipment items, such as towers, reactors, exchangers, pumps, etc., and the associated installation costs, including foundations, erection, piping, instruments, painting, etc. Other important costs, here designated as outside battery limits (OSBL) include site preparation, buildings and furnishings, utilities plant, storage, fire and safety, OSBL piping and other auxiliary facilities. Both ISBL and OSBL costs will include engineering, contractor's fee and usually a contingency allowance.

Project X — Startup Costs



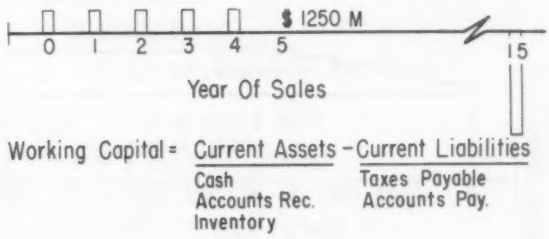
Once construction is complete, the plant must be started up. Startup costs consist of those presale operating costs required to bring the plant on stream. It includes employee training and repiping and other investment alterations as well as the usual manufacturing costs. It is generally assumed that no revenue is obtained from products made during this period. Frequently, part of this startup cost is capitalized. The startup cost for Project X is assumed to total $1,250,000. This includes a three-month period of employee training prior to startup, and a six-month startup period. All startup costs are treated as expense.

Project X — Sales Forecast



Once the plant is started up, sales begin. The sales forecast for Project X is shown above. A uniform sales growth is assumed, beginning at 20 percent capacity in the first year, 40 percent in the second and so forth. The price is assumed to be 50¢/lb. for the first two years of sales, dropping to 45¢/lb. the next three years and 40¢/lb. thereafter. These prices represent the net sales realization on Project X—that is, the gross sales revenue less any returns, discounts, freight and allowances.

Project X — Working Capital

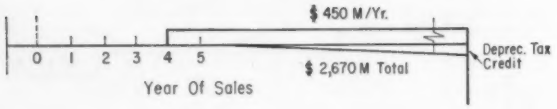


To operate the plant, working capital is required. These are the funds in addition to fixed capital, land investment and startup costs, which a company must contribute to the project to get the plant operating and meet subsequent obligations as they come due. Requirements are assumed proportional to sales level and completely recoverable at the end of the project without loss. Total working capital for Project X is $1,250,000.

The major components of working capital are shown above. The net requirement is the difference between current assets and current liabilities for the project. The first is the sum of incremental cash requirements, accounts receivable from customers and inventories required of raw materials, other supplies, intermediates

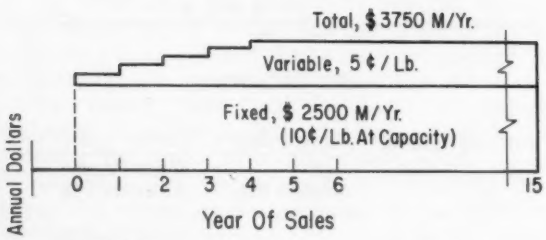
and finished products. Deductions include accounts payable to suppliers, wages and insurance payable, and taxes payable, both U.S. and local. The Federal tax credit is quite significant and frequently omitted. Its importance can be measured by the fact that the government's current deferred payment schedule permits an average accumulation of cash equal to about seven months of taxes.

Project X — Modernization Capital
(Sustaining Capital)



Here is an item not too frequently recognized in evaluations. We call it modernization capital, or sustaining capital. This is the fixed capital requirement to maintain the competitive position of a project throughout its commercial life by improving product quality, related services or economy. Capital for those improvements that generate savings is only partially modernization capital. The excluded portion is the fixed capital supported at project profitability by the savings generated. In this particular project, modernization capital was approximated by considering it to be a constant $450,000/year beginning in the fifth year of sales. This is depreciated in the normal manner and the appropriate tax credit taken, including a tax credit for the undepreciated balance at the end of the project life.

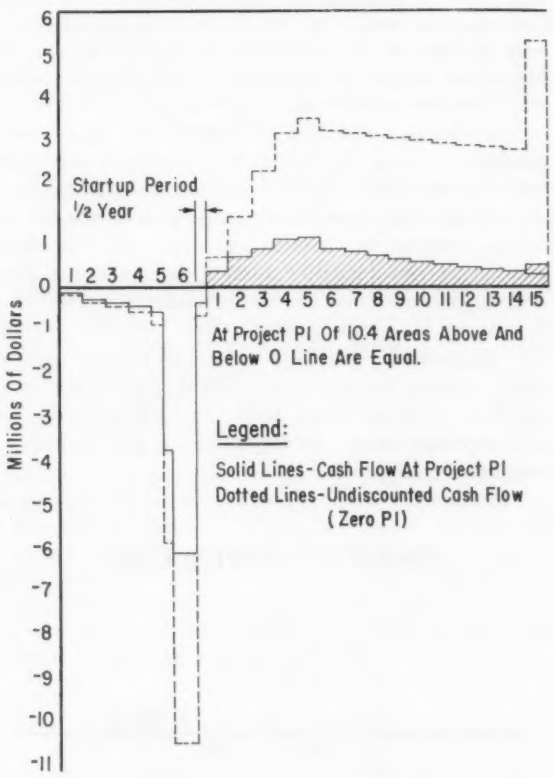
Project X — Annual Expenses



Variable	Fixed
Raw Materials	Operating Labor ¢ Maintenance
Utilities	Tech. Service ¢ Lab.
Catalyst ¢ Chemicals	Taxes ¢ Insurance
Packaging	Plant Overhead
	Sales, Admin., Research

So far a lot of investment has been put into Project X and its startup. Now some money must be spent to keep the plant running. The forecast annual expenses are shown above. These are divided into two main categories—fixed costs and variable costs. The fixed costs, taken as $2,500,000 per year or 10¢/lb. of capacity production, are those costs independent of short term variations in plant output. Included are such things as labor, maintenance, technical service and laboratory expense, taxes and insurance, plant overhead and sales, administrative and research expense. For the purpose of cash flow calculations, depreciation—a non-cash expense—is excluded. (Its effect on income tax calculations has been discussed with fixed capital.) Variable costs, the other major expense category, include raw material costs, by-product credits and those processing costs directly proportional to plant output such as utilities, catalysts and chemicals, and packaging. The variable costs of this project are taken as 5¢/lb.

Project X — Composite Cash Flow Schedule


Millions Of Dollars
6 5 4 3 2 1 0 -1 -2 -3 -4 -5 -6 -7 -8 -9 -10 -11
Startup Period
½ Year
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
At Project PI Of 10.4 Areas Above And Below 0 Line Are Equal.
Legend:
Solid Lines - Cash Flow At Project PI
Dotted Lines - Undiscounted Cash Flow (Zero PI)

The net cash flow of after-tax dollars for Project X is summarized above. Investments and net annual expenses lie below the base line. Net cash receipts are shown as positive cash flows. The dashed line shows the cash flows at zero PI, or before discounting. On this basis, the net receipts towards the end of the project are much greater than the net dollars out-of-pocket initially. Discounting these cash flows by the standard trial and error procedure shows a total project PI of 10.4. A plot of these discounted cash flows at project PI is shown by the solid line on the chart. Since this line is drawn at project PI, the areas above and below the base line are equal. The relatively small significance of receipts far in the future is clearly evident. For example, the discounted plant investment is about half the amount of its undiscounted value, while discounting reduces the value of receipts in the last ten years of sales by a factor of about 10.

Incomplete Estimates Mislead

	PI	
	Change	Total
Total Project, Including All Cost Elements	—	10.4
Omissions:		
1. Development Costs	+1.4	
2. Price Decline	+2.1	
3. Sales Build up	+6.0	
4. Working Cap., Mod. Cap.	+1.1	
5. Startup Costs	+0.5	
6. Plant Construction Period	+2.1	
Project PI, Incomplete Evaluation	—	23.6

As shown above, incomplete estimates can be misleading. The correct PI for this hypothetical Project X is 10.4. Through oversights, the evaluator might omit certain things—some with more frequency than others. He might, for example, fail to recognize development costs. For Project X, his calculated PI would then be 1.4 units high. His forecast might also fail to recognize the future price declines. Then his estimate would be 2.1 units higher. He might assume capacity sales at the beginning instead of forecasting the buildup. For Project X, this would be his worst error, increasing PI another 6.0 units. These three omissions alone—and they are fairly common ones in preliminary evaluations—raise PI 9.5 units to 19.9, a value almost twice the project PI found when all costs and revenues were considered. If the evaluator was doing a real hurry-up job, he might possibly ignore working capital and modernization capital. The extreme novice might forget startup costs and plant construction period. These would inflate the PI another 3.7 units. For this very incomplete evaluation, the PI is 23.6 or almost 2½ times that found for the complete estimate. It is thus fairly obvious that omissions or over-simplifications can lead to serious errors in judgment.

ESTIMATE RELIABILITY MUST BE RECOGNIZED

In addition to omissions, of course, there are uncertainties surrounding each estimate item. Hence, presentation of a single PI number can be misleading even if no obvious omissions exist. For a project near commercialization, the range of uncertainty is generally fairly small and can be estimated with some reliability. In such an instance, an evaluator could say the project PI would vary between one specific number and another, and be done with it. However, in many cases, particularly when the development is in its early stages, people will simply throw up their hands and say, "I don't know how good my estimate is." A way around this latter problem is to calculate a PI sensitivity —the change in a given variable required to produce a one PI change from the base case. This technique shows which variables are most important in determining project profitability and where estimation errors are likely to be unimportant.

PI Sensitivities — Project X in Decreasing Importance

	Change In Costs/PI	
	%	Absolute
Selling Price	4.5	2.3¢
Fixed Capital	14	$ 2100 M
Fixed Costs	18	1.8¢
Variable Costs	45	2.3¢
Development Costs	85	$ 2500 M
Modernization Capital	130	$ 600 M/Yr.
Working Capital	210	$ 2600 M
Startup Costs	240	$ 3000 M

Some Project X sensitivities are shown above. They are listed in decreasing importance and reported as the change in costs required to produce one PI change from the base case of 10.4 PI. Changing the base case would, of course, change these sensitivity figures somewhat. It is interesting to note the very powerful effect of selling price—roughly a 5 percent or 2¢/lb. change will alter the project PI one unit. In comparison, a 14 percent fixed capital change or an 85 percent change in development costs or a 240 percent change in startup costs is required to produce a similar effect. For this project, selling price, fixed capital, fixed costs and variable costs are the most important of the variables listed.

Consider Several Economic Criteria

Rate Of Return

- Profitability Index
- Cash Return, % Of Total Capital

Size

- Fixed Or Total Capital
- Maximum Out-Of-Pocket Cash
- Cumulative Cash Proceeds

Sensitivity To Variables

- PI Sensitivities
- Breakeven Point
- Payout Of Fixed Capital
- Net Profit, % Of Net Sales
- Turnover Ratio, (Sales / Investment)

Up to this point, the profitability index has been treated as if it were the sole criterion of profitability. This is certainly not the case. As pointed out at the beginning, it is certainly not necessary and probably is undesirable to go into this complexity when com-

paring projects with equivalent time patterns. Assuming even the complex project, however, several economic criteria are better than one. Several of these criteria are shown above. These criteria are classified into three groups: rate of return, size, sensitivity to variables.

A rate of return is an efficiency ratio, relating profit or cash flow incomes to investments. The **profitability index** is felt to be the best measure, as it utilizes the single, most important, fundamental, (and often least recognized) concept of economic analysis—the time value of money. **Cash return**—after tax profit plus depreciation—as **percent of total capital** is a useful measure too. It measures rate of return at capacity operations. It is easy to understand, and under certain limiting conditions, closely approximates the calculated PI return.

Size is also an important criterion. Often, the development costs for a new chemical will be about the same regardless of the size of the ultimate commercial plant. Hence, a big success will normally benefit a company more than a small success. Also management can properly consider only a certain number of opportunities at one time—a few big jobs should not be buried because of the problems of a large number of small ones. Fixed or total capital, maximum out-of-pocket cash, and cumulative cash proceeds are all useful measures of size.

Lastly, there are the various sensitivities of the project to the various variables. PI sensitivities, previously discussed, certainly are very important. Break-even point, the fraction of plant capacity at which sales revenue just covers all fixed and variable costs (including depreciation) is another useful landmark. Payout of fixed capital in years, net profit on sales and turnover ratio are other partial criteria that indicate certain general characteristics of the project.

Consider turnover ratio, for example. This is the ratio of sales to investment and is typically about unity for many chemical projects. A project with a high turnover normally has a low percent profit on sales and is more sensitive to price fluctuations than a project with low turnover ratio. In fact, it is possible to find projects where a single PI answer becomes meaningless because of the extreme sensitivities to small uncertainties in incomes and expenditures. In such cases qualitative factors and general business judgment may become the over-riding factors in management's decision.

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About the Authors

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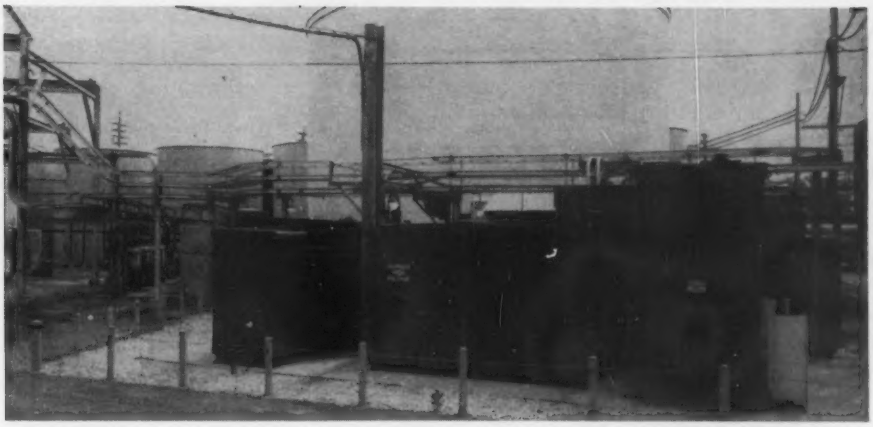

FIGURE 1—This outdoor substation in a non-hazardous area feeds the wax plant.

Why Atlantic Used Armor Cable in Division 2 Areas

- You can save 10-15 percent over the cost of conduit and wire if several cables are traveling in the same direction
- Although not approved by NEC, the petroleum industry recognizes overhead cable installations as being comparable to conduit and wire

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APPROXIMATELY 25,000 FEET of interlocked armor cable in aluminum trays has been installed in The Atlantic Refining Company's new paraffin wax plant. Because the cable cost was 15 percent lower than conduit and wire, the cost of the entire cable tray system was almost covered in the cable cost savings alone.

Code Requirements. Interlocked armor cable installations in the petroleum industry are very few in number compared to conduit and wire. This is because interlocked armor cable is relatively new, and the National Electrical Code (NEC) has not yet recognized it as a wiring method for use in Division 2 areas.

The petroleum industry, however, is recognizing overhead armor cable installations as being comparable to conduit and wire as evidenced in the American Petroleum Institute's Publication RP-540, which notes that armor cables may be considered for use in Class I, Group D, Division 2 areas. The API is presently in the process of requesting NEC approval for the use of armor cables in Division 2 areas.

Why Use Interlocked Armor Cable? Atlantic's electrical specifications do not approve underground installations because of the congested pipeline network below grade and the oily condition of the soil. Their specified wiring method is overhead conduit and wire, with an alternate permitting the use of interlocked armor cable, provided the installed cost is not greater than that for a conduit and wire system.

Wax Plant Feeders. The plant is fed from an outdoor unit substation located in a non-hazardous area just be-

Why Atlantic Used Armor Cable . . .

yond the plot limits, as shown in Figure 1. Feeders to the wax plant from the substation are:

- 1—13 KV, 3000 HP motor feeder
- 4—Control cables for the 3000 HP motor temperature detectors, differential control, and alarm leads
- 2—2300 V. group motor control feeders
- 1—2300 V. normal lighting serving feeder
- 1—2300 V. emergency lighting service feeder
- 4—440 V. group motor control feeders

These cables average 300 feet in length. Although all of the cables in Division 2 areas were ultimately installed as interlocked armor cable, the decision to use armor cable was based on this particular group.

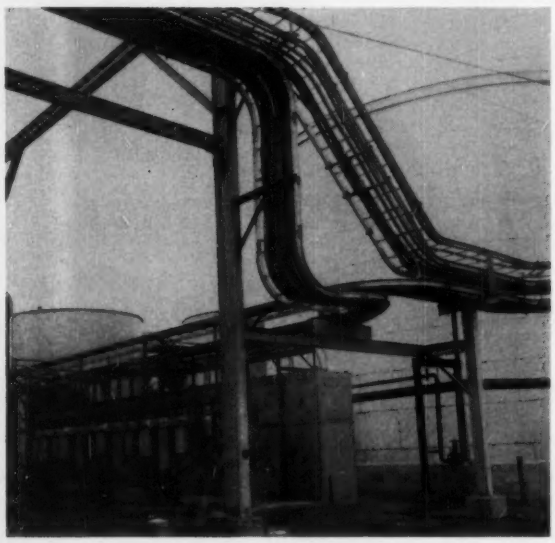

FIGURE 2—Aluminum cable trays were easier to install and offer greatly improved corrosion resistance over galvanized steel trays.

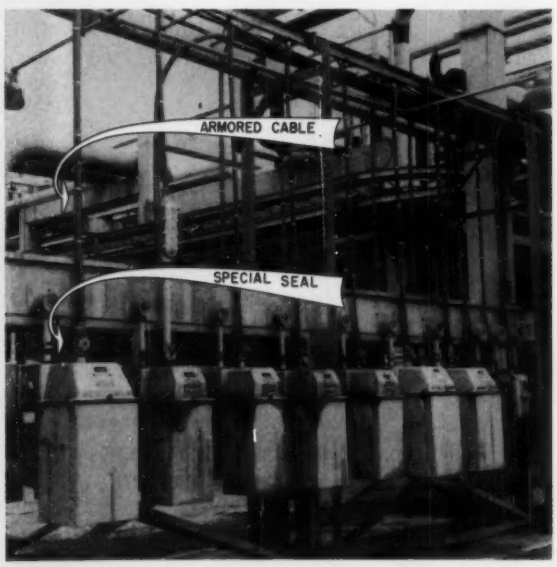

FIGURE 3—A special sealing method was used at each terminal housing.

Investigations showed that for this group:

- The average weight of conduit and wire is 75 pounds per foot higher than that for cable, 145 pounds against 70 pounds.
- Neglecting cost of fittings and terminations, the interlocked armor cable cost was 15 percent lower than the cost of conduit and wire.
- Corrosion resistant light weight aluminum cable trays were readily available for the interlocked armor cable, whereas supports for the conduit system would have to be custom designed and fabricated of galvanized steel. Also, the trays were less costly than the steel supports.
- The cost of the cable tray system could almost be covered with the savings in the cable cost as noted above.

At this point it appeared very strongly that the installed cost of an armor cable system for this plant would be less costly than a conduit and wire system; therefore the decision was made to use armor cable for all Division 2 areas. The possible saving in labor was not a significant factor in making this decision since, at the time, work on a cable system would be unfamiliar to most electricians. As installation experience is gained, the savings in the cable system will naturally increase and become an added benefit of the cable system.

Specifications. The cable has a galvanized steel armor with a covering of polyvinyl chloride for corrosion protection. This outer covering is color coded to identify cable by voltage levels: 600 V.—Green; 2300 V.—Yellow; 13000 V.—Red; Thermocouple—Blue, and Air Tubing—Black.

(Note: Green may not have been the best choice since it is an industry standard color for ground wires.)

The 15 KV and 5 KV cables are insulated with varnished cambric* and have an additional PVC jacket under the armor. The 600-volt cables have Type TW insulation with a binder tape under the armor.

Selection of Cable Trays. Aluminum cable trays (Figure 2) were selected over galvanized steel for the reasons that the 61-S-T6 aluminum alloy used in these trays offered greater resistance to corrosion in this refinery; also, their light weight provided ease of installation and allowed greater span between supports.

Ladder type trays were selected over basket type because of the greater ease of feeding cables into and out of the trays. The spacing between the rungs is 18 inches.

The multilayer trays are tied together with vertical supports on 6⅔-foot centers, with an open clearance of 11 inches between the layers.

The tray system was designed to facilitate the installation of the cables, with no cable being bent to a radius smaller than seven times the cable's outside diameter during installation.

Installation. The light-weight trays were shipped to the plant site in standard lengths. They are installed on galvanized steel wall brackets where convenient, and on overhead galvanized steel supports elsewhere.

* At the time of this installation, varnished cambric cable was available and the industry had experience in handling it.

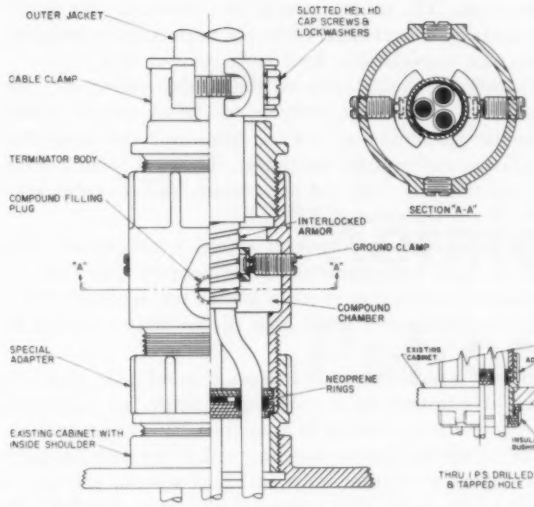

FIGURE 4—The compound portion of this connector provides the necessary seal.

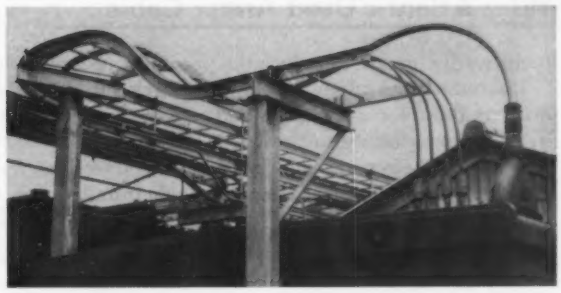

FIGURE 5—Potheads with compound filled terminators receive the cable.

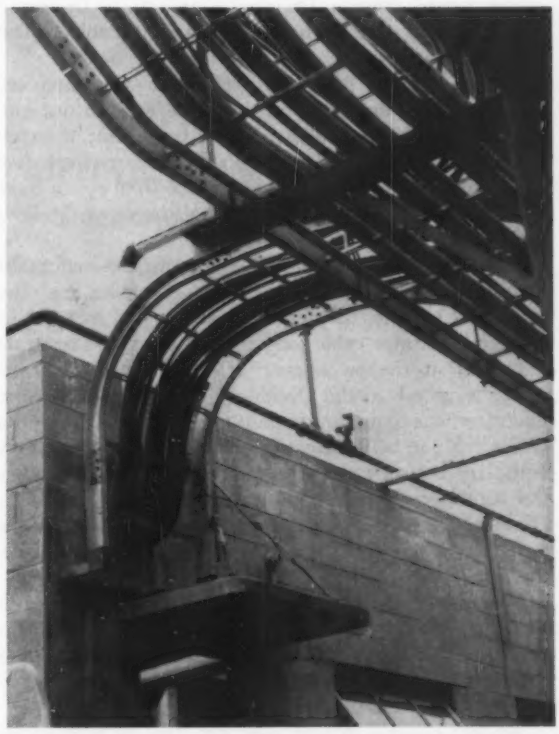

FIGURE 6—Instrument air tubing cables are also carried on the trays.

To prevent galvanic corrosion between the aluminum trays and the steel supports, polyvinyl plastic tape is wrapped around the tray at the supporting locations to a thickness of 20 mils. This taping procedure isolated the trays from ground; therefore, it was necessary to connect ground wires to the trays. Tinned lugs were used for this purpose.

The armor cables were pulled into the trays with the aid of rollers and pulleys. The rollers were spaced about 12 feet apart to reduce friction on the horizontal runs, and the pulleys facilitated making the bends.

A pulling eye was used to put most of the pulling strain on the conductors, and a basketweave pulling grip was installed over the armor to prevent snagging on the tray rungs.

The cable pulling operation was completed without too much difficulty. The biggest problem was pulling the cables around the several vertical and horizontal offsets in the tray system. Such offsets should be kept to a minimum when a new system is designed.

The cables are held in the trays by formed aluminum cable clamps that snap into the tray rungs. The clamps are spaced 4½ feet on the horizontal runs, and two feet on the vertical runs.

The 600-volt TW-insulated cables are terminated with watertight cable connectors for armor with outer jacket. These connectors are not compound filled, but use a rubber grommet for watertightness. There are three grounding set screws in the connector body that are tightened into the armor for purposes of grounding the armor. Since these connectors are not compound filled, a separate sealing means had to be provided at each termination, as shown in Figure 3. To accomplish this, a short length of conduit with a standard sealing fitting was installed in each terminal housing. The cable connector was screwed into this conduit. Sufficient length of armor was removed to allow the conductors to continue through the conduit and into the terminal housing without splicing.

The 5,000-volt varnished cambric-insulated cables are terminiated with compound filled terminators that include an armor grounding screw. The compound portion of this connector provides the necessary seal, as shown in Figure 4.

The 15-KV varnished cambric-insulated cables are terminated in potheads that include compound filled terminators to receive the interlocked armor cable (Figure 5).

Instrument Service. Thermocouple leadwire and annunciator leads were run in armor multi-conductor cable from the control room instruments to terminal boxes near the center of the field connections. At the time of this installation multipair thermocouple leadwire cables were not readily available so it was necessary to purchase leadwire in single pair construction and have it made into ten pair cable by a cable manufacturer. Even today this frequently proves to be an economical way of purchasing multipair leadwire cable. Terminals used with thermocouple leadwire were coated with a high

temperature grease to reduce the possibility of corrosion.

Instrument air tubing cables were carried in the same trays as those for instrument and power cables (Figure 6). This opportunity to provide a common support system for both electrical and instrument connections was an added economy of the electrical cable installation.

General Design Notes. As previously mentioned, API Publication RP-540 notes that armor cables may be considered for use in Division 2 areas. However, under no circumstances are they to be used in Division 1 areas. Conduit and wire is the proper installation for these areas. In this wax plant there were two locations where cables passed from a Division 2 area to a Division 1 area. In these cases transformations from cable to conduit were required.

At one location, fifteen 440-volt cables were involved. Space was not available on the cable rack to use individual splice boxes for each cable transition; therefore standard compound filled cable splice fittings were used. These fittings not only used less space than splice boxes but also eliminated the need for seals between the Division 1 and Division 2 areas.

At the other location, a 15-KV motor-feeder cable was involved. Since splices in high voltage cables are often sources of trouble, the decision was reached to purchase a length of armor cable long enough to extend from the terminals in the switchgear at the substation to the motor terminals in the Division 1 area. The cable manufacturer was requested to omit the armor on the section of the cable to be installed in the Division 1 area. At the boundary between the Division 1 and Division 2 areas the conductors were continued in the conduit into the Division 1 area without splicing. A compound filled interlocked armor cable terminator was used to terminate the armor cable where it entered the conduit.

Motor push-button control circuits are included in the same cable as the power wiring for 600 volt service or less where the power wires are smaller than number 2/0. This feature considerably reduced the number of cable runs in this plant.

No fire protection was used on this installation because the overhead cable system was installed over an open area where the fire hazard is at a minimum. However, transite was used on the bottom and sides of the trays on another similar cable installation where the cables run over a congested pump area. A recent flash fire proved the value of this design because the transite completely protected the cables.

Installation Problems. This is the first refinery installation of interlocked armor cable by Atlantic, and because it was the first there were more than the usual number of installation problems encountered. To assist others who are not familiar with armor cable, the authors feel that some of the major installation problems should be mentioned.

- As a labor saving feature, the tray system should be kept as simple as possible with a minimum of offsets for ease in pulling the cables.
- There was considerable difficulty in matching the connectors with the cables received on the site. The actual cable dimensions were not in accordance with the manufacturer's quoted dimensions that were used to order the connectors. The cable size and the connector sizes should be carefully coordinated when the materials are ordered; otherwise considerable field time may be lost.
- During the installation of the cable connectors, care should be taken not to remove too much armor; otherwise the grounding screws will penetrate the conductor insulation and ground the system. This was quite a problem on this job since the electricians had no experience with these terminators.
- In those outdoor locations where a compound filled type of cable terminator would be permitted by Code or Insurance authorities to serve also as the explosion-proof seal, the compound filled type of terminator should be used.
- Where a conventional explosion-proof seal must be used in addition to a cable terminator, an improved type of cable connector is available. This connector includes a silicone rubber bushing which the manufacturer states gives a weather tight seal that tests to 100 psi or more gas pressure. This improved connector also includes a spring steel sleeve which fits between the grounding set screws and the armor.
- This improved construction should greatly reduce the possibility of forcing the armor or the grounding set screws through the wire insulation.

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Burpee

Thermo Data for Petrochemicals

Part 27: Gaseous Normal Aldehydes. The important thermo properties are presented for all the gaseous normal aldehydes from formaldehyde through decaldehyde

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FOR ORGANIC COMPOUNDS other than hydrocarbons only a small amount of thermodynamic data is available. In most cases data are known only for the first term, or the first few terms, of the homologous series. The lack of thermodynamic data is felt particularly strong if one tries to build up a correlation between structure and thermodynamic properties (see Part 26 of this series). One is then compelled to calculate for groups other than hydrocarbons the contributions of the nonhydrocarbon parts of the organic compound from the first term, or the first few terms, of a homologous series. As is well known, however, the behavior of these terms deviates from the additive behavior of the higher terms of such a series. Consequently, the reliability of a group contribution calculated in this way is not very great.

However, in the case of several classes of compounds it is possible to achieve a reasonable degree of accuracy in the calculation of thermodynamic properties for a complete series.

The following is a description of such a calculation for the normal aldehydes.

METHOD OF CALCULATION

Literature Data. In literature the thermodynamic properties of gaseous formaldehyde[2] and acetaldehyde[3] are given as functions of temperature.

Further, the entropy of liquid butyraldehyde and liquid heptaldehyde at 25° C are known[4]

$$C_3H_7CHO\ (l)\ S^{\circ}_{298.15\ ^{\circ}K} = 59.0\ \frac{cal}{mole\ ^{\circ}K}$$

$$C_6H_{13}CHO\ (l)\ S^{\circ}_{298.15\ ^{\circ}K} = 83.3\ \frac{cal}{mole\ ^{\circ}K}$$

These data, in combination with the vapor tension of butyraldehyde[5] and that of heptaldehyde[6] lead to

$$\left.\begin{aligned} C_3H_7CHO\ (g)\ S^{\circ}_{298.15\ ^{\circ}K} &= 82.4 \pm 1.0\ \frac{cal}{mole\ ^{\circ}K} \\ \text{and } C_6H_{13}CHO\ (g)\ S^{\circ}_{298.15\ ^{\circ}K} &= 110.3 \pm 1.0\ \frac{cal}{mole\ ^{\circ}K} \end{aligned}\right\}$$ The inaccuracy is estimated

Determining the heat consumed in the hydrogenation of gaseous acetaldehyde to gaseous ethyl alcohol at 355 °K, Kistiakowsky and coworkers,[7] found

$$\Delta H^{\circ}_{\substack{hyd \\ 355\ ^{\circ}K}} = -16.752 \pm 0.100\ \frac{kcal}{mole}$$

from which, after reduction to 25° C, it follows that

$$\Delta H^{\circ}_{\substack{hyd \\ 298.15\ ^{\circ}K}} = -16.47 \pm 0.10\ \frac{kcal}{mole}$$

Kistiakowsky and coworkers[7] assumed this heat of hydrogenation to be independent of the length of the

hydrocarbon chain. (This assumption was supported by measurements of the heat effect observed in the hydrogenation of ketones[7] and alkylenes.)[8, 9] From a very accurate measurement of the heat of combustion Tjebbes[10] calculated the heat of formation, ΔH_f°, from the elements:

$$C_3H_7CH\ (l)\ \underset{298.15\ ^\circ K}{\Delta H_f^\circ} = -57.06 \pm 0.17\ \frac{kcal}{mole},$$

from which, using the heat of evaporation calculated from the vapor tension,[5] one finds

$$C_3H_7CHO(g)\ \underset{298.15\ ^\circ K}{\Delta H_f^\circ} = -48.95 \pm 0.47\ \frac{kcal}{mole}.$$

Combination of this value with the heat of formation of gaseous *n*-butyl alcohol[11] leads to the following value of the heat consumed in the hydrogenation of butyraldehyde to *n*-butyl alcohol

$$\underset{298.15\ ^\circ K}{\Delta H_{hyd}^\circ} = -18.12 \pm 0.86\ \frac{kcal}{mole}$$

which is not in accordance with the expectations of Kistiakowsky and coworkers.[7]

From what has been said above it follows that the heat consumed in the hydration of the aldehydes to the corresponding alcohols is not constant. Therefore, the heats of formation for gaseous aldehydes higher than butyraldehyde were calculated starting from the assumption that the contribution made to the heat of formation by a $-CH_2-$ group is equal to the contribution by a $-CH_2-$ group of the olefin with the same number of carbon atoms. This calculation leads to the following results:

Aldehyde	$-\Delta H^\circ_{f_{298.15}}$ kcal/mole
CH_3CHO	39.81 ± 0.32
C_2H_5CHO	44.40 ± 0.40
n C_3H_7CHO	48.95 ± 0.47
n C_4H_9CHO	53.92 ± 0.67
n $C_5H_{11}CHO$	58.88 ± 0.87
n $C_6H_{13}CHO$	63.81 ± 1.07
n $C_7H_{15}CHO$	68.74 ± 1.27
n $C_8H_{17}CHO$	73.66 ± 1.47
n $C_9H_{19}CHO$	78.59 ± 1.67

Thermodynamic Properties of Propionaldehyde. In the calculation of the thermodynamic properties of the higher aldehydes use must be made of the data for propionaldehyde. These were calculated from molecular data.

It was assumed that, on the analogy of what is known for CH_3CHO,[3] one may take for propionalhehyde $r_{C-C} = 1.50$ Å; $r_{C-H} = 1.09$ Å; $r_{C=O} = 1.22$ Å; $\sphericalangle$ HCO = 120°; all other angles were considered to be tetrahedral. It follows that $I_1I_2I_3 = 1.181.10^{-114}$ g^3cm^6.

A good interpretation of the whole spectrum of propionaldehyde is lacking. The following fundamental vibrations were chosen:

C—C—C bending 265 cm^{-1}	C—H wagging 1392 cm^{-1}
C—C=O bending 512 cm^{-1}	C—H stretching 2724 cm^{-1}
C—C stretching 846; 996 m^{-1}	(Values according to Seewan-
C—H rocking 893 cm^{-1}	Albert and Kahovec)[12]

For CH_2 the generalized vibrations according to Pitzer[13] were chosen, viz. 940 cm^{-1}; 1278 cm^{-1}; 1338 cm^{-1}; 1460 cm^{-1}; 2950 (2) cm^{-1}; the CH_3 vibrations were derived from those obtaining for acetaldehyde,[3] viz. 883 cm^{-1}; 913 cm^{-1}; 1370 cm^{-1}; 1414 cm^{-1}; 1440 cm^{-1}; 2950 (3) cm^{-1}. This procedure is analogous to the one used by Kirpatrick and Pitzer[14] for butylene.

By means of these data the contributions of translation, external rotation, and vibration were calculated.

TABLE 1*—Specific Heats for Gaseous Normal Aldehydes

Compound	Formula	Temp. °K								
		298.15	300	400	500	600	700	800	900	1000
		C_p° cal/mole °K								
Formaldehyde	HCHO	8.45	8.47	9.37	10.44	11.50	12.48	13.36	14.13	14.80
Acetaldehyde	CH_3CHO	13.06	13.10	15.73	18.27	20.52	22.50	24.20	25.68	26.96
Propion aldehyde	C_2H_5CHO	18.80	18.87	23.09	26.89	30.22	33.03	35.45	37.55	39.27
n-Butyraldehyde	C_3H_7CHO	24.52	24.61	30.2	35.2	39.6	43.4	46.6	49.3	51.7
n-Pentaldehyde	C_4H_9CHO	29.96	30.08	37.1	43.4	49.0	53.7	57.7	61.1	64.0
n-Hexaldehyde	$C_5H_{11}CHO$	35.43	35.57	44.0	51.7	58.3	63.9	68.7	72.9	76.4
n-Heptaldehyde	$C_6H_{13}CHO$	40.89	41.07	51.0	59.9	67.7	74.2	79.8	84.6	88.7
n-Octaldehyde	$C_7H_{15}CHO$	46.36	46.56	57.9	68.2	77.0	84.5	90.9	96.4	101.0
n-Nonaldehyde	$C_8H_{17}CHO$	51.82	52.06	64.8	76.4	86.4	94.8	101.9	108.1	113.4
n-Decaldehyde	$C_9H_{19}CHO$	57.29	57.55	71.8	84.7	95.7	105.0	113.0	119.9	125.7

*In order to retain internal consistency, the values in this and the following tables are given to more decimal places than is justified by the accuracy of the calculations.

TABLE 2—Enthalpy Function for Gaseous Normal Aldehydes

Compound	Formula	Temp. °K								
		298.15	300	400	500	600	700	800	900	1000
		$\frac{H^\circ - H_0^\circ}{T}$ cal/mole °K								
Formaldehyde	HCHO	8.02	8.03	8.25	8.58	8.98	9.41	9.85	10.29	10.71
Acetaldehyde	CH_3CHO	10.30	10.32	11.34	12.47	13.63	14.76	15.84	16.86	17.81
Propion aldehyde	C_2H_5CHO	13.12	13.14	15.11	17.09	19.02	20.81	22.49	24.14	25.50
n-Butyraldehyde	C_3H_7CHO	16.92	16.95	19.6	22.2	24.8	27.1	29.4	31.5	33.4
n-Pentaldehyde	C_4H_9CHO	20.22	20.26	23.6	27.0	30.2	33.2	36.0	38.7	41.0
n-Hexaldehyde	$C_5H_{11}CHO$	23.55	23.60	27.7	31.7	35.6	39.2	42.6	45.9	48.7
n-Heptaldehyde	$C_6H_{13}CHO$	26.88	26.95	31.7	36.5	41.1	45.3	49.3	53.0	56.4
n-Octaldehyde	$C_7H_{15}CHO$	30.21	30.29	35.8	41.3	46.5	51.4	55.9	60.2	64.0
n-Nonaldehyde	$C_8H_{17}CHO$	33.54	33.64	39.9	46.1	52.0	57.4	62.6	67.4	71.7
n-Decaldehyde	$C_9H_{19}CHO$	36.87	36.98	43.9	50.8	57.4	63.5	69.2	74.6	79.3

The contribution made by internal rotation was calculated as shown below.

At 25° C the following relations apply

$$S^{\circ}_{CH_3CHO} - S^{\circ}_{CH_3CH=CH_2} = -0.65 \frac{cal}{mole\ ^{\circ}K}$$

$$S^{\circ}_{nC_3H_7CHO} - S^{\circ}_{nC_3H_7CH=CH_2} = -0.25 \frac{cal}{mole\ ^{\circ}K}$$

$$S^{\circ}_{nC_6H_{13}CHO} - S^{\circ}_{nC_6H_{13}CH=CH_2} = -0.25 \frac{cal}{mole\ ^{\circ}K}$$

So that, approximately

$$S^{\circ}_{C_2H_5CHO} = S^{\circ}_{C_2H_5CH=CH_2} - 0.25$$

and hence

$$S^{\circ}_{\substack{C_2H_5CHO \\ 298.15\ ^{\circ}K}} = 72.8 \pm 1.0 \frac{cal}{mole\ ^{\circ}K}$$

(The entropy values for the mono-olefins were taken from the well-known API publication.)[1]

From the difference between this entropy and the sum of the contributions made by translation, external rotation and vibration, the energy barrier to the rotation of the $-\overset{\overset{O}{\|}}{C}-H$ group about the C — C bond was calculated by Pitzer's well-known method.[15,16,17,18] (The rotation barrier for the CH_3 group was chosen to be 3400 $\frac{cal}{mole}$, on the analogy of that for butylene.)[13] The result thus obtained was $V\text{-}c_H = O = 1800 \pm 800 \frac{cal}{mole}$. This is in reasonable agreement with the barrier for the $-\overset{\overset{O}{\|}}{C}-H$ group in acetaldehyde,[3,19] ($V\text{-}c_H = O = 1000$; 1150 $\frac{cal}{mole}$). An estimation for the rotation of the $-\overset{\overset{O}{\|}}{C}-O$ group in the butyraldehyde molecule gave $Vc_H = O = 2000 \pm 800 \frac{cal}{mole}$.

The total thermodynamic properties of propionaldehyde and other aldehydes are given in the Tables 1, 2, 3 and 4.

Thermodynamic Properties of the *n*-Aldehydes. The thermodynamic properties of the higher aldehydes were calculated by means of the "method of increments"[20,21,22] developed by the API research group. This calculation gave

$$\phi(C_nH_{2n+1}CHO) = \phi(C_2H_5CHO) + \phi(C_nH_{2n+1}CH=CH_2) - \phi(C_2H_5CH=CH_2) \quad (n > 2)$$

where

$$\phi = C^{\circ}_p;\ \frac{H^{\circ} - H^{\circ}_o}{T};\ -\frac{G^{\circ} - H^{\circ}_o}{T} \text{ resp. } S^{\circ}$$

The thermodynamic properties calculated in this way are given in the tables 1, 2, 3 and 4. It is seen that the entropies of *n*-butyraldehyde and heptaldehyde thus calculated agree very closely with the values derived from the measurements referred to above.

By means of the above mentioned heats of formation of the gaseous *n*-aldehydes at 25° C the free enthalpies and heats of formation of these compounds between 298.5 °K and 1000 °K were calculated (see the tables 5 and 6).

The thermodynamic properties of formaldehyde and acetaldehyde were derived from publication by Thompson[2] and Pitzer and Weltner.[3]

From the values given in table 6 and the contribution of the hydrocarbon groups [23] the following increment is found for the contribution made by the $-\overset{\overset{H}{|}}{C}-O$ group

$$\Delta G^{\circ}_f H = -29.160 + 0.663.10^{-2}\ T \quad (300 \ldots 600\ ^{\circ}K)$$

$-C{=}O$

TABLE 3—Entropies of Gaseous Normal Aldehydes

Compound	Formula	Temp. °K								
		298.15	300	400	500	600	700	800	900	1000
		S° cal/mole °K								
Formaldehyde	HCHO	52.28	52.34	54.89	57.12	59.09	60.94	62.66	64.29	65.82
Acetaldehyde	CH_3CHO	63.15	63.25	67.37	71.14	74.68	78.00	81.12	84.06	86.84
Propion aldehyde	C_2H_5CHO	72.83	72.93	78.94	84.41	89.73	94.60	99.17	103.56	107.53
n-Butyraldehyde	C_3H_7CHO	82.44	82.59	90.4	97.6	104.5	110.9	116.9	122.7	127.9
n-Pentaldehyde	C_4H_9CHO	91 72	91.90	101.50	110.4	118.9	126.8	134.3	141.3	147.8
n-Hexaldehyde	$C_5H_{11}CHO$	101.03	101.24	112.6	123.2	133.3	142.7	151.6	160.0	167.8
n-Heptaldehyde	$C_6H_{13}CHO$	110.34	110.59	123.8	136.0	147.7	158.7	169.0	178.7	187.7
n-Octaldehyde	$C_7H_{15}CHO$	119.65	119.93	134.9	148.9	162.2	174.6	186.3	197.4	207.7
n-Nonaldehyde	$C_8H_{17}CHO$	128.96	129.27	146.0	161.7	176.6	190.5	203.6	216.1	227.7
n-Decaldehyde	$C_9H_{19}CHO$	138.27	138.61	157.1	174.5	191.0	206.4	221.0	234.8	247.6

TABLE 4—Free Energy Function of Gaseous Normal Aldehydes

Compound	Formula	Temp. °K								
		298.15	300	400	500	600	700	800	900	1000
		$-\frac{G^{\circ} - H^{\circ}_o}{T}$ cal/mole °K								
Formaldehyde	HCHO	44.25	44.30	46.64	48.54	50.11	51.53	52.81	54.00	55.11
Acetaldehyde	CH_3CHO	52.85	52.93	56.03	58.67	61.05	63.24	65.28	67.20	69.03
Propion aldehyde	C_2H_5CHO	59.71	59.79	63.83	67.32	70.71	73.79	76.68	79.42	82.03
n-Butyraldehyde	C_3H_7CHO	65.52	65.67	70.8	75.4	79.7	83.8	87.5	91.2	94.5
n-Pentaldehyde	C_4H_9CHO	71.50	71.64	77.9	83.4	88.7	93.6	98.3	102.6	106.8
n-Hexaldehyde	$C_5H_{11}CHO$	77.48	77.64	84.9	91.5	97.7	103.5	109.0	114.1	119.1
n-Heptaldehyde	$C_6H_{13}CHO$	83.46	83.64	92.0	99.5	106.6	113.4	119.7	125.7	131.3
n-Octaldehyde	$C_7H_{15}CHO$	89.44	89.64	99.1	107.6	115.6	123.2	130.4	137.2	143.6
n-Nonaldehyde	$C_8H_{17}CHO$	95.42	95.63	106.1	115.6	124.6	133.1	141.1	148.7	155.9
n-Decaldehyde	$C_9H_{19}CHO$	101.40	101.63	113.2	123.7	133.6	143.0	151.8	160.2	168.2

TABLE 5—Heat of Formation of Gaseous Normal Aldehydes

Compound	Formula	Temp. °K									
		0	298.15	300	400	500	600	700	800	900	1000
		ΔH_f° kcal/mole									
Formaldehyde	HCHO	—27.70	—28.62	—28.62	—29.03	—29.42	—29.78	—30.10	—30.37	—30.59	—30.78
Acetaldehyde	CH_3CHO	—37.30	—39.81	—39.83	—40.63	—41.33	—41.92	—42.40	—42.79	—43.10	—43.32
Propion aldehyde	C_2H_5CHO	—40.45	—44.40	—44.43	—45.50	—46.42	—47.16	—47.77	—48.24	—48.51	—48.82
n-Butyraldehyde	C_3H_7CHO	—43.86	—48.95	—48.98	—50.35	—51.52	—52.43	—53.23	—53.74	—54.12	—54.37
n-Pentaldehyde	C_4H_9CHO	—47.54	—53.92	—53.96	—55.67	—57.06	—58.20	—59.10	—59.76	—60.13	—60.49
n-Hexaldehyde	$C_5H_{11}CHO$	—51.22	—58.88	—58.93	—60.94	—62.64	—63.97	—65.03	—65.78	—66.13	—66.51
n-Heptaldehyde	$C_6H_{13}CHO$	—54.86	—63.81	—63.86	—66.19	—68.15	—69.68	—70.88	—71.76	—72.13	—72.53
n-Octaldehyde	$C_7H_{15}CHO$	—58.51	—68.74	—68.79	—71.44	—73.65	—75.39	—76.74	—77.75	—78.13	—78.55
n-Nonaldehyde	$C_8H_{17}CHO$	—62.15	—73.66	—73.73	—76.70	—79.16	—81.09	—82.59	—83.73	—84.14	—84.57
n-Decaldehyde	$C_9H_{19}CHO$	—65.79	—78.59	—78.66	—81.95	—84.67	—86.80	—88.45	—89.72	—90.14	—90.59

TABLE 6—Free Energy of Formation for Gaseous Normal Aldehydes

Compound	Formula	Temp. °K									
		0	298.15	300	400	500	600	700	800	900	1000
		ΔG_f° kcal/mole									
Formaldehyde	HCHO	—27.70	—27.19	—27.18	—26.64	—26.00	—25.25	—24.49	—23.49	— 22.82	— 21.95
Acetaldehyde	CH_3CHO	—37.30	—31.92	—31.87	—29.09	—26.12	—22.99	—19.84	—16.59	— 13.29	— 9.88
Propion aldehyde	C_2H_5CHO	—40.45	—29.67	—29.58	—24.46	—19.05	—13.51	— 7.92	— 2.20	+ 3.58	+ 9.56
n-Butyraldehyde	C_3H_7CHO	—43.86	—27.38	—27.25	—19.49	—11.95	— 3.89	+ 4.12	+12.39	+ 20.69	+ 29.27
n-Pentaldehyde	C_4H_9CHO	—47.54	—25.40	—25.23	—15.39	— 5.08	+ 5.45	+16.03	+27.33	+ 37.66	+ 48.88
n-Hexaldehyde	$C_5H_{11}CHO$	—51.22	—23.43	—23.21	—10.97	+ 1.74	+14.80	+27.87	+41.15	+ 54.66	+ 68.49
n-Heptaldehyde	$C_6H_{13}CHO$	—54.86	—21.42	—21.16	— 6.54	+ 8.62	+24.18	+39.78	+55.60	+ 71.67	+ 88.06
n-Octaldehyde	$C_7H_{15}CHO$	—58.51	—19.41	—19.10	— 2.11	+15.50	+33.56	+51.69	+70.05	+ 88.68	+107.63
n-Nonaldehyde	$C_8H_{17}CHO$	—62.15	—17.40	—17.05	+ 2.32	+22.39	+42.95	+63.60	+84.50	+105.69	+127.20
n-Decaldehyde	$C_9H_{19}CHO$	—65.79	—15.39	—15.00	+ 6.75	+29.27	+52.33	+75.51	+98.95	+122.69	+146.77

$$\Delta G_f^\circ \; \underset{-C=O}{H} = -30.102 + 0.802.10^{-3}\, T \quad (600 \ldots 1000\ ^\circ K)$$

(The constants in this formula are given to more decimal places than is justified by the accuracy of the calculations.)

With the help of this group contribution the free enthalpy of formation of the normal gaseous aldehydes can be calculated with an accuracy of $\pm$ 0.5 $\frac{kcal}{mole}$ (maximum deviation).

NOMENCLATURE

C_p° = specific heat at constant pressure $\left[\frac{cal}{mole\ ^\circ K}\right]$

$\frac{H^\circ - H_o^\circ}{T}$ = enthalpy function $\left[\frac{cal}{mole\ ^\circ K}\right]$

$\frac{G^\circ - H_o^\circ}{T}$ = free enthalpy function $\left[\frac{cal}{mole\ ^\circ K}\right]$

S° = entropy $\left[\frac{cal}{mole\ ^\circ K}\right]$

ΔH_{hydr}° = heat of hydration (enthalpy) $\left[\frac{kcal}{mole}\right]$

ΔH_f° = heat of formation (enthalpy) form the elements $\left[\frac{kcal}{mole}\right]$

ΔG_f° = free enthalpy of formation (Gibbs free energy) $\left[\frac{kcal}{mole}\right]$

V_A = rotation barrier for the A group $\left[\frac{cal}{mole}\right]$

The super script index $^\circ$ refers to the standard state. (The ideal gaseous state at a fugacity of one atmosphere.)

T = temperature [°K]

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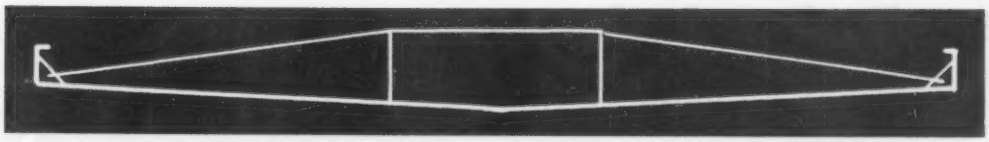
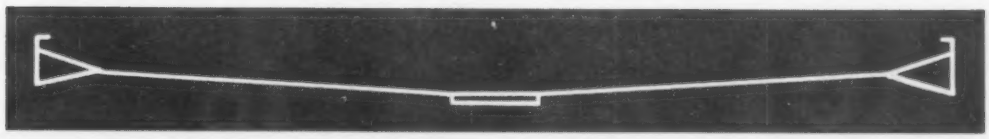
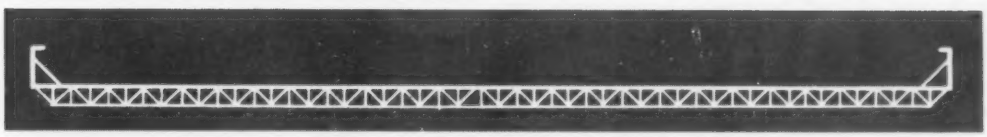


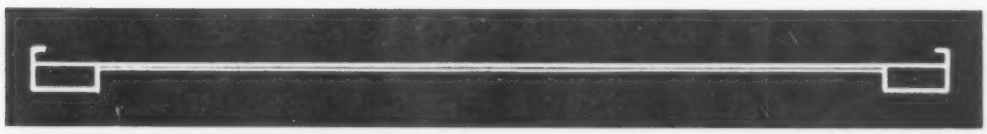
Trussed Pan Roof



Pan Roof With Center Weight



Pan Roof With Underdeck Truss



Pan Roof With Underdeck Girder

FIGURE 1—Pan type floating roofs get their name from the upstanding rim at the periphery.

For crude or product storage . . .

Choose the Right Floating Roof Tank

Which should you use: the pan, pontoon or double deck type floating roof?

Robert W. Bodley
Graver Tank and Manufacturing Co.
East Chicago, Ind.

SELECTING the right type of floating roof involves three decisions:

- How much money can you spend?
- How much protection do you need against sinking or tipping and buckling under load?
- And, how close must you control evaporation losses?

To answer these questions, the engineer has a choice of three general types of floating roofs, pan, pontoon and double deck—and a number of roof appurtenances. The pan type of roof is usually the cheapest and the double deck type will give you the greatest structural protection as well as hold evaporation losses to a minimum.

Cost. Naturally, the most economical design must sacrifice some features, and it logically follows that the most expensive type generally offers the most desirable features. The roof with the least amount of materials is usually the least costly.

Structural Performance is governed primarily by the considerations of buoyancy and stability. Buoyancy requirements for pontoon and double deck roofs are set in the main guide to floating roof design API Standard 12-C, Appendix C. However, stability of the design is left to the tank manufacturer. The buoyancy requirements in this standard offer a high degree of protection against sinking by allowing for unlikely combinations of pontoon and single deck leakage. Stability as applied

to floating roofs includes both resistance to tipping and resistance to distortion and buckling. Stability is required to prevent tipping under load, or if a leak develops in service. Under conditions of heavy load, tipping or rim distortion can lessen the effectiveness of the seal.

Manufacturers use different ways to provide the required stability and some are proprietary. Floating roof experience shows that modern roofs have sufficient buoyancy and stability to meet normal operating conditions. The degree of protection afforded depends upon the type and design of roof, as will be discussed under each type of roof. Structural performance can also be affected by the operation of some appurtenances such as rim vents, drains, and ladders.

Evaporation Losses. In a properly designed and placed floating roof, almost all the evaporation losses occur in the seal area, and are consequently small. However, losses can become excessive in warm climates if the vapor formed under single deck roofs is allowed to escape. Therefore, in many cases it is desirable to design single deck roofs so that they will trap the vapor thereby providing an insulating space above the product surface.

In a recent test, deck and product temperatures were measured by thermo-couples on a 150-foot-diameter pontoon type floating roof. The results, in Table 1, can be used as a guide in choosing a roof to prevent product boiling. Temperatures were measured over two summers in both the single deck and pontoon areas. Part of the time, the single deck portion was vented so that it remained in contact with the liquid, while part of the time, vapor was trapped to form an insulating vapor space. The first summer the roof and tank shell were not painted, while the following summer they were painted white. Table 1 shows the *peak* surface temperatures recorded for various ranges of average atmospheric temperature, and combinations of painting and roof construction. Reid vapor pressures shown are those of products which would exert 14.7 psia at the indicated surface temperatures. No actual double deck measurements were taken. Figures shown for double deck roofs were taken from readings in the pontoon area.

TABLE 1—Peak Surface Temperatures and Corresponding Reid Vapor Pressures of Products that can be Stored Under Floating Roofs Without Boiling

Average Atmospheric Temperature	NO PAINT			WHITE PAINT		
	SINGLE DECK		Double Deck Or Under Pontoon	SINGLE DECK		Double Deck Or Under Pontoon
	Full Contact	Trapped Vapor Space		Full Contact	Trapped Vapor Space	
50-60	150F-6	108F-12	101F-14	*	*	*
60-70	150F-6	113F-11.5	108F-12	107F-12.5	95F-16.0	88F-17.0
70-85	*	131F- 8.5	115F-11	120F- 8.5	104F-13.0	95F-16.0

* No Data.

As an example of what the table shows, if the average summertime atmospheric temperature of a locality is in the range of 70° F to 85° F, an 11-psi Rvp gasoline can be stored under a double deck roof without boiling if it is not painted. But, if the roof is painted, a 16-psi Rvp stock can be safely stored. Also, for a white painted pontoon or pan roof that will trap vapor, a 13-psi Rvp gasoline can be stored without boiling.

Pan Type Floating Roofs are comparatively low in initial cost because they consist simply of a single deck roof which floats on the product. At the periphery of

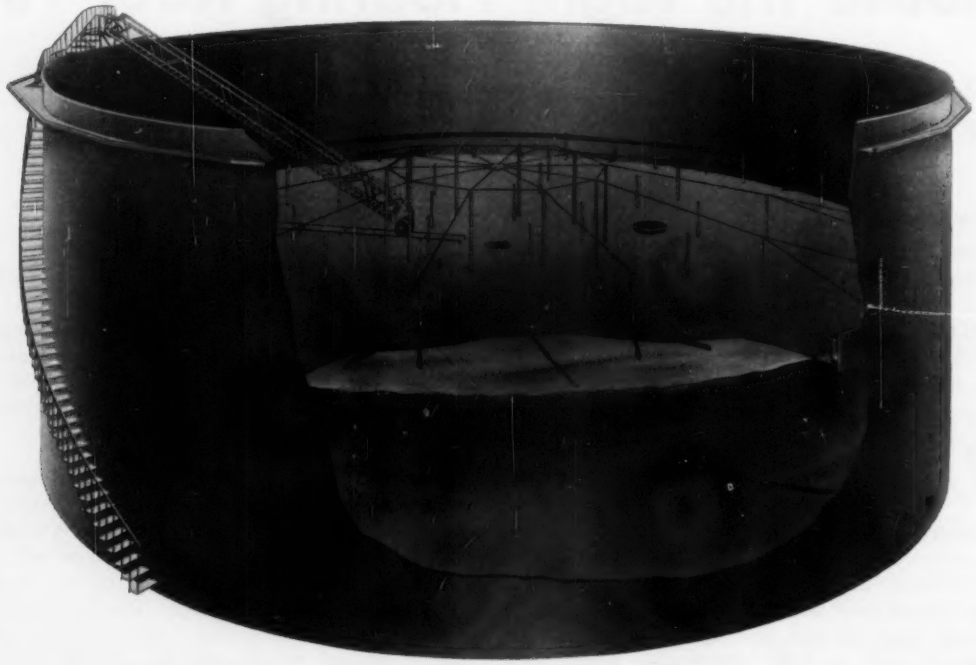
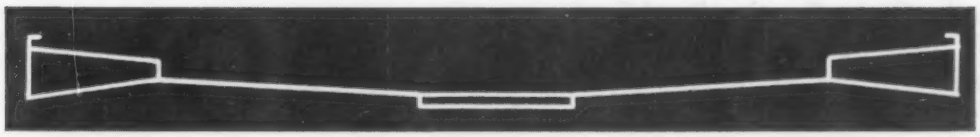
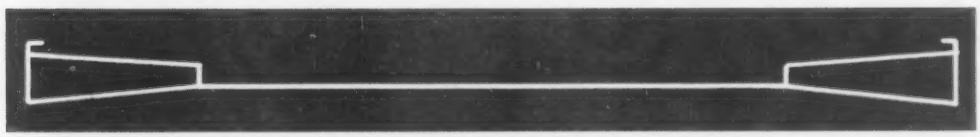


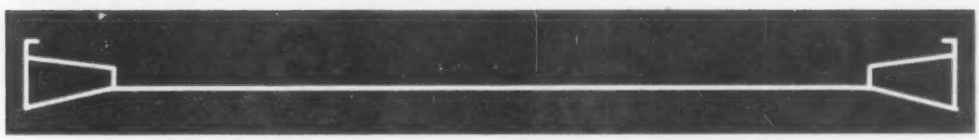
FIGURE 2—The trussed pan roof was the first floater to gain wide acceptance.



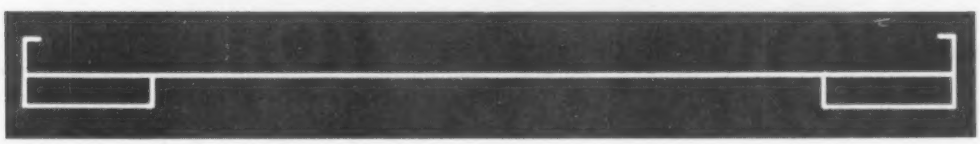
Pontoon Roof With Center Weight



Pontoon Covering 50 percent of Roof Area



Pontoon Roof to Meet Minimum Requirements of API-12C, 16th Edition



Pontoon Roof With Deck Raised Off Product

FIGURE 3—Pontoon type floating roofs have been used widely in severe summer and winter climates.

the roof is an upstanding rim which gives the roof floating characteristics similar to those of a saucer or pie pan and provides the means for attaching a seal. Figure 1 shows various types of pan roofs available. The trussed pan roof was the first floater to gain wide acceptance, and Figure 2 is an artist's rendering of such a roof. Other, more recent designs use weights at the center, underdeck trusses or girders to hold the roof in a conical shape. Two designs use a small pontoon to replace the lifting effect at the rim provided by the tie rods in the trussed pan type.

Since the pan is a single-deck roof, an unchecked leak through this deck will eventually cause it to sink. It has no buoyancy other than that provided by the deck and rim.

Alone, pan roofs are stable structures, nevertheless, they are the most easily affected by a load, such as snow or rain. As it is applied, the roof sinks deeper into the product. So long as the roof stays level and the rim and deck are intact, there is ample buoyancy. However, as a roof is loaded, the rim is thrown into compression and will begin to deform. As the load is increased, the rim distortion magnifies, with the rim leaning alternately inward and outward around the circumference. Under reasonable loads this is not severe, but if allowed to progress too far the distortion can cause a poor fit of the seal. One test on a 117-foot-diameter pan roof showed pronounced deformation with the accumulation of a two-inch rainfall. A small pontoon around the rim helps this; nevertheless, pan roofs have limited load carrying ability.

Maintenance inspections should be more frequent for trussed pan roofs than for the other designs. Rods should be kept in proper adjustment. Also, there are more corrosion starting points. Thus the clear deck designs offer reduced maintenance costs.

By nature of its design, the trussed pan roof cannot trap vapor. The types with a small pontoon, however, can trap vapor, to form an insulating space.

All of the above considerations enter into the selection of these roofs. Consequently, because of their low cost, trussed pan roofs have been widely used for the storage of crude oils in mild climates. Pan roofs that trap vapor can be applied to both crudes and gasolines in the same areas.

Having only a single deck in contact with the product, it is necessary that the drainage system be of the closed or syphon type. Open drains cannot be used on these single deck roofs because the product level is initially higher than the deck and rises faster than water as the roof is flooded. The different types of drains are described later.

Pontoon Type Floating Roofs represent significant improvements over the pan types. Buoyancy and stability are increased, as is the insulation of the product from the sun. As a result, these roofs have been widely used in both severe winter and summer climates, and on corrosive and noncorrosive poducts with vapor pressures up to 15 psia.

Obviously it is possible to build pontoon floating roofs with any desired size of pontoons, to meet a specific service need. However, economy dictates the setting of standards which provide safe designs for

the average range of service conditions. Also, tank manufacturers provide differences in design features. Therefore, as with pan roofs, there are several types of pontoon roofs some of which are pictured in Figure 3. Figure 4 is an artist's rendering of a pontoon roof. Although all of these roofs are classed generally as pontoon roofs, they have varying sizes of pontoons. For many years it was common for the pontoons to be 15 to 18 inches deep and to cover from about 30 to 50 percent of the roof area depending upon the particular design of the manufacturer. In the past several years however, since the API Appendix on floating roofs was written, roofs to meet this specification have become popular. Pontoon areas on these roofs range from about 20 to 40 percent.

All of these roofs normally have sufficient calculated pontoon volume to meet the buoyancy and load carrying requirements of Appendix C. With the pontoon type roof, two compartments and the single deck can leak at the same time, and the remaining compartments have sufficient buoyancy to support the roof on a 0.7 specific gravity product. Pontoon volume, and thus safety factor against sinking, obviously depends upon pontoon depth as well as width, so the yardstick of percent pontoon area can be misleading. However, it is generally true that the new smaller width pontoons meet the API conditions while the larger widths exceed them and offer additional safety. Additional load carrying capacity is desirable where heavy snow accumulations are common.

The buoyancies above are calculated buoyancies with no external loads on the deck. Tipping from other causes such as unbalanced snow should be guarded against. Anticipated water loads are not as critical as expected snow loads since they are concentric and can be more easily removed. Nevertheless these roofs are able to carry a considerable water load. API 12-C says that "the pontoon volume and emergency drainage, either in combination or separately, shall be such that a 10-inch rainfall over the entire area during a 24-hour period will not cause the roof to sink if the primary drainage is inoperative (with no compartments or decks punctured)." Most of these roofs can hold a full 10-inch rainfall accumulation.

The first three pontoon roofs in Figure 3 can be made for full liquid contact when desired. All of the roofs can trap vapor under the single deck—a very important conservation feature as shown by Table I. Obviously, the more area covered by pontoons, the better will be the insulating value of the roof.

With these roofs, it is necessary that the drainage system be of the closed or siphon type. Open drains cannot be used on them for the same reasons as mentioned under pan roofs. If a roof is built so that the pontoon covers about 60 percent or more of the roof area, an open drain can be used as either a primary or an emergency drain, for then the water on the deck will rise sufficiently faster than the product to reach the top of an overflow pipe before the product does.

Double-Deck Floating Roofs. Generally described, the double-deck floating roof, comprises upper and lower decks separated by bulkheads and trusses as shown in Figure 5. Circular bulkheads divide the entire roof into annular liquid-tight compartments (customarily referred to as pontoons) and some of these compartments are in turn divided into liquid-tight sectors by means of radial bulkheads. Radial trusses are dispersed throughout to provide the required stength and stability. Because of its obviously superior load capacity and insulating characteristics, the double deck roof is used extensively for protecting all types of products in all climates.

Double deck roofs have a high ratio of pontoon volume to unit weight. Theoretically, anywhere from about 60 to 85 percent of the pontoons can leak, and the roof will still be buoyant. These figures are not so important for double deck roofs, however, since multiple pontoon leaks are rare. Indeed, single pontoon leaks are uncommon. Floating roof decks and pontoons are thoroughly leak-tested before a roof is put into service. Therefore, sufficient leakage to cause sinking

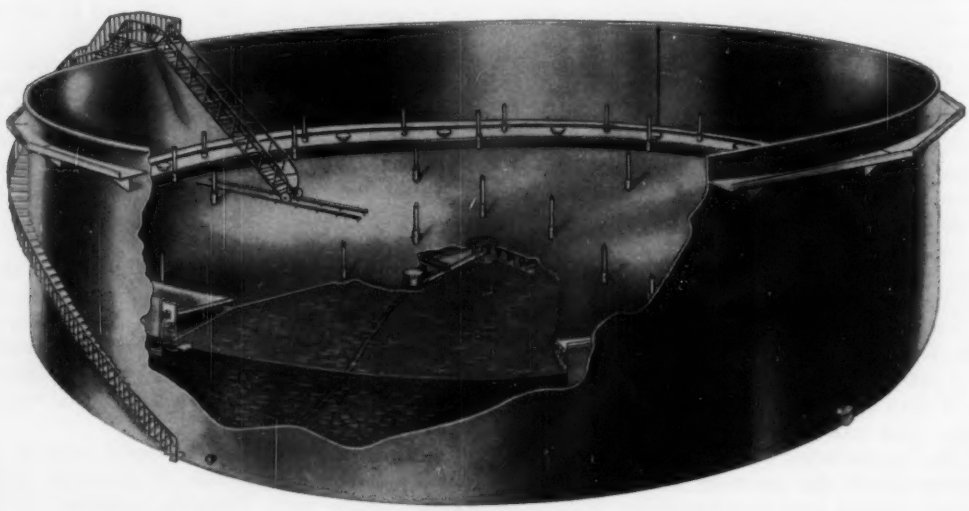


FIGURE 4—Pontoon areas range from about 20 to 40 percent of the roof area.

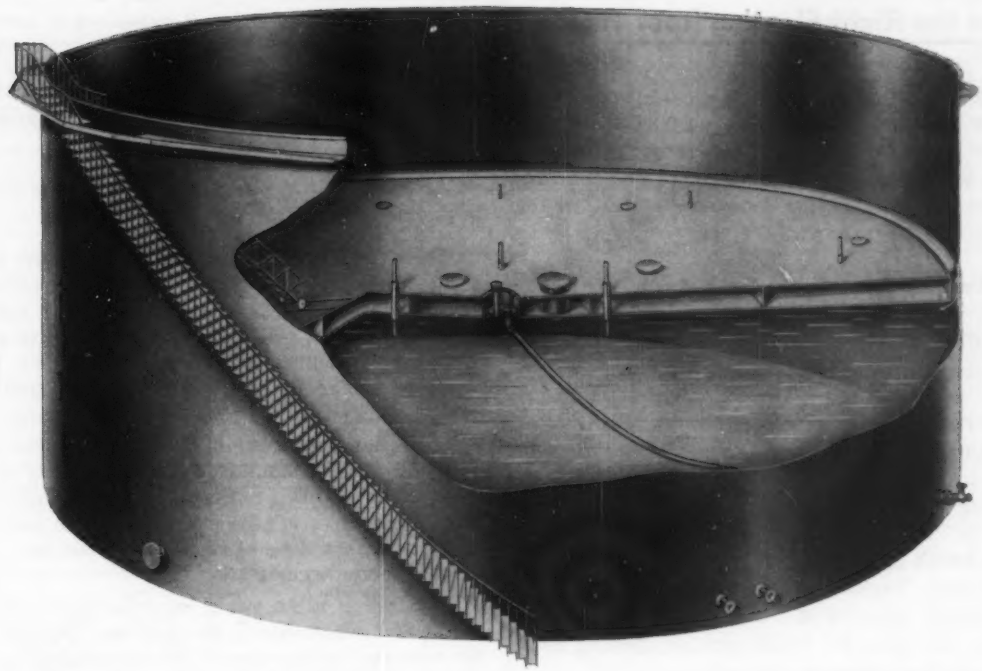


FIGURE 5—Double deck floating roofs have upper and lower decks separated by bulkheads and trusses.

of a pontoon or double deck roof is improbable. These figures were quoted here to show the high degree of safety afforded.

Open drains can be used on double deck roofs of any diameter, and are usually installed as emergency drains. The double deck roof has the buoyancy and stability to support a 10-inch rainfall accumulation. For rainfall, however, this is academic since that amount of rain cannot collect, because it is carried off by the emergency drains.

Because of its excess buoyancy and rigidity, the double deck roof can support heavy snow loads. However, if these loads are eccentric, tipping will result. Off center loading can, of course, lead to trouble.

As shown earlier in Table 1, double deck roofs can protect products up to 17 psia Rvp without boiling. Vapor trapping is not necessary. Consequently, the bottom decks can be sloped either up or down.

Floating Roof Drains. Drains are necessary to remove accumulated water from the floating roof.

Open drains can only be used on doube decks (or specially designed pontoon roofs). They allow water to flow into the stored product, where it settles to the bottom to be drawn off later. They are also used as emergency drains on double deck roofs when closed drains are provided.

A siphon drain is an open pipe, with screened top, having a bottom water reservoir. It is used on single deck roofs. The water reservoir seals against the product and prevents its flow onto the deck. Therefore, the water seal must always be full.

A hose drain conducts water from a central sump on the roof to outside the tank through a shell nozzle. On pan and pontoon roofs, a swing check valve and plug are installed at the sump end of the hose to keep the product from running onto the roof should the hose leak. A valve is also installed at the shell end to prevent loss of product in case of a failure. A positioning device can be used with the hose to keep it from kinking or being crushed by a pipe post.

Similar to the hose drain is the pipe drain, except that steel pipes with flexible pipe joints are used. Valves must be used in the same manner as with hose drains for single deck roofs.

FLOATING ROOF APPURTENANCES

Adjustable pipe supports keep the roof from resting on the tank bottom when the tank is empty or nearly so. They hold the roof about three feet off the bottom during normal operation, and six feet for cleaning or inspection. Other elevations can be had by special design. API 12-C sets the design load for these posts at the roof weight plus a 25-pound-per-square-foot live load. This is equivalent to five inches of water.

Vents must be used to provide air under the roof as the tank is emptied or to relieve pressure as the tank is filled. They can be either weighted combination pressure-vacuum vents, or bleeder vents operated by engaging the tank bottom.

Manways, or openings in the deck or pontoons, are necessary for inspection and cleaning operations of the roof. The through deck manways are bolted and gasketed to seal against vapor leakage, but pontoon manways are normally of the loose cover type so that inspections can be made easily.

The rolling ladder provides the means for getting on the roof, no matter what its elevation, from the top shell platform. A rung type ladder is usually furnished but self-leveling stair tread designs can be provided.

An anti-rotation device keeps the roof from rotating during product level changes and thereby prevents damage to the rolling ladder, pipe drain, swing line and gaging equipment.

A gage hatch provides access through the roof to the product level. To facilitate hand gaging, a platform area is usually designed at the top of the tank so that the gager can open the hatch with an opening cable, without climbing down to the roof.

OPERATION AND MAINTENANCE

Floating roof tanks are subject to the ravages of weather, and as discussed under each type of roof, are designed to withstand them. It is impossible however, to assure by design, permanent, satisfactory operation, no matter the conditions. For this reason, it is wise for the operator to know and understand the limitations of floating roofs, so he can take them into account in daily operation.

Excessive external loads of water or snow must be guarded against. When floating, a roof will withstand a much heavier uniform or concentric load than it will an off-center load. Tipping must be checked, especially on trussed pan and pontoon type roofs. Also, water and snow must be removed, even if concentrically located, when the load gets heavy. It is difficult to estimate the weight of a snow or water load so rim depth and out of level tolerances are a better guide. Good, general rules to follow are:

- If a roof gets more than 3 inches out of level around the rim, the load should be evened.
- For pan and pontoon roofs, when the floating depth increases about 3 inches all the way around, the load should be removed.
- An increase in depth of 10 inches can be allowed on double deck roofs.

These are, as stated, general and not fast rules but they can be used as a guide. As discussed earlier, pontoon and double deck roofs have superior load carrying ability. Also, generally, smaller diameter roofs are more stable than those with larger diameters. External loads on the roof also affect tank gages, and for this reason, water is often removed before gaging.

Snow build up around the rolling ladder must be removed and the track cleared before filling or emptying the tank. This is especially important before filling, since it could tip the roof or damage the ladder. Ladder tracks should be elevated above the deck in areas of heavy snow accumulation.

If a roof is to be out of service, resting on its legs, in an area where heavy snowfalls are common, it may be necessary to use timber shores to help carry snow accumulation. This, however, is very rarely a problem. In summer climates, when a roof is out of service, the drains should be open to keep water from accumulating. Some single deck roofs come equipped with screwed deck plugs and these should be removed.

The roof end of hose and pipe drains on pan and pontoon roofs are usually plugged except when water is being removed. This keeps product from flowing onto the deck in case of a break in the drain and a leak in the check valve. Similarly, the valve at the tank end is usually kept closed or prevent loss of product. When product temperatures are likely to drop below freezing, the drain should be cleared of water (blown out if necessary) and closed. Snow accumulation then must be shovelled off, and water can be siphoned into the product or over the shell.

It is wise to check the seal for freezing to the tank shell before a receipt or delivery, when there has been a rain followed by freezing. No cases of damage to the seal from this cause have been reported, but the possibility exists.

Vents require normal good maintenance practice. Failure to operate can cause damage to the roof or seal. Bleeder vents must be adjusted to the correct height for bottom contact, at the same time as pipe support levels are set. A pin similar to those on the pipe supports is usually provided.

For products of low volatility, it is often desirable to fill at a slower rate than normal until the roof is floating. Static charges can build up on the liquid surface from turbulent filling, and the space below the roof can be in the explosive range.

Normal good painting practice is also required. As shown earlier, white paint does much to reduce product temperatures. Other, less reflecting paints can be used depending upon the type of product and roof.

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About the Author

Bodley

Robert W. Bodley is the assistant manager of project research with Graver Tank & Mfg. Co., East Chicago, Ind. He supervises research and development projects in the field of petroleum conservation and has been associated with Graver since 1948 when he received a BS degree in mechanical engineering from Purdue University. Mr. Bodley is a registered professional engineer in the State of Indiana and has been a member of the American Petroleum Institute's Evaporation Loss committees since their inception.

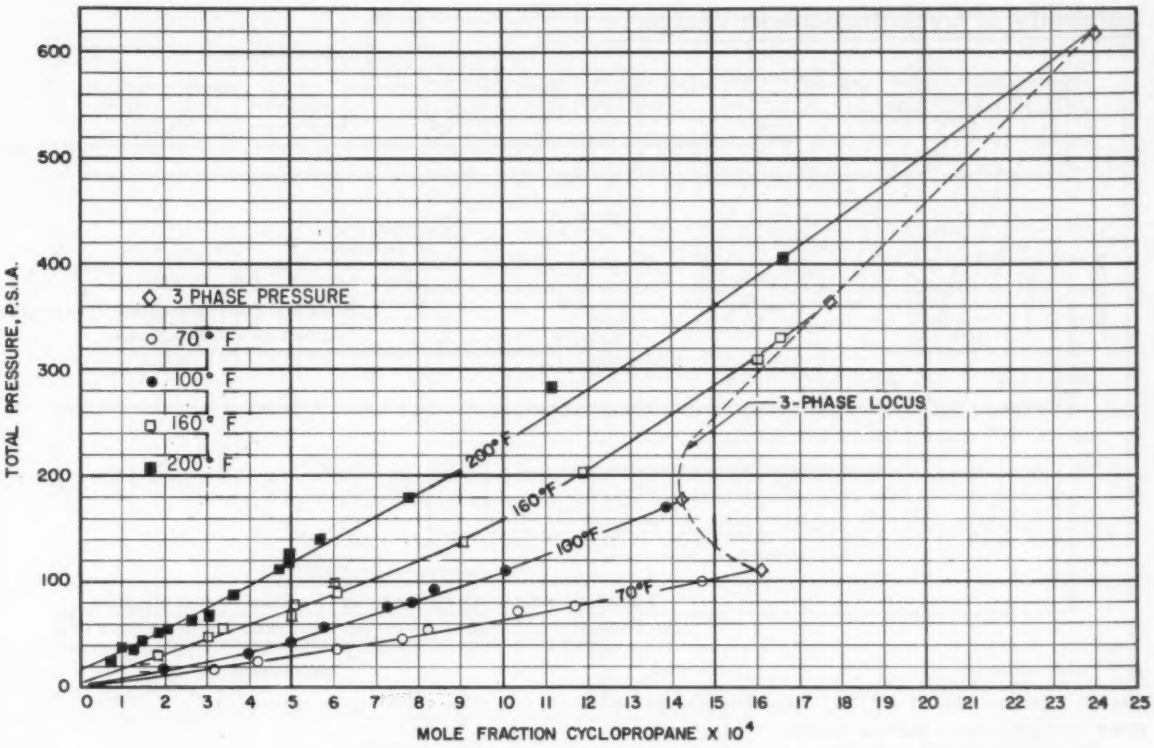

FIGURE 1—Solubility of cyclopropane in water.

Solubility of Cyclopropane in Water

Ruben F. Inga* and John J. McKetta
The University of Texas, Austin

THIS IS THE RESULT of an experimental determination of the solubility of cyclopropane in water at pressures to 620 psia for a temperature range of 70° to 220° F. No solubility data for cyclopropane have been found in the literature for elevated pressures. Orcutt and Jeevers[2] determined the Ostwald coefficient for cyclopropane at temperatures of 68° to 100° F at atmospheric pressure. They found that the solubility of cyclopropane was about twice that of ethylene.

The equilibriating equipment and analytical techniques were essentially the same as those described earlier.[1] A static method was used whereby the cyclopropane and water are added to an equilibrium cell. The cell was rocked for an hour at constant temperature. The cell was then kept at rest for 30 minutes to allow complete separation of the phases. The water-rich liquid phase was then sampled directly into the analytical train.

Materials Used. The water was taken from the laboratory distilled water supply and boiled to remove any dissolved gases. The cyclopropane was research grade material furnished by Phillips Petroleum Company. A mass spectrometer analysis of the hydrocarbon showed the purity to be above 99.7 percent cyclopropane.

EXPERIMENTAL RESULTS

The experimental data for the solubility of cyclopropane in water are shown in Table 1. These data are also shown in Figure 1 as a function of pressure at temperatures of 70°, 100°, 160° and 220° F. The reproducibility of the data was considered very good especially considering the extremely low concentration of the hydrocarbons in the water phase.

The smoothed data are shown in Table 2. The effect of temperature on the composition of the water-rich liquid phase is shown in Figure 2. It can be seen from Figure 2 that the minimum solubility phenomenon which is usually associated with hydrocarbon-water systems is not present in the cyclopropane-water system in this pressure and temperature range.

ACKNOWLEDGMENTS

This work was carried out under a National Science Foundation Grant. The authors also wish to acknowledge the assistance of Phillips Petroleum Company who supplied the research grade cyclopropane.

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[1] Azarnoosh, A. and McKetta, J. J., Petroleum Refiner, 37, No. 11,275 (1958).
[2] Orcutt and Jeevers, *J. Pharmacol*, 59, 206 (1937).

* Present address: International Petroleum Company, Lima, Peru.

Solubility of Cyclopropane in Water. . .

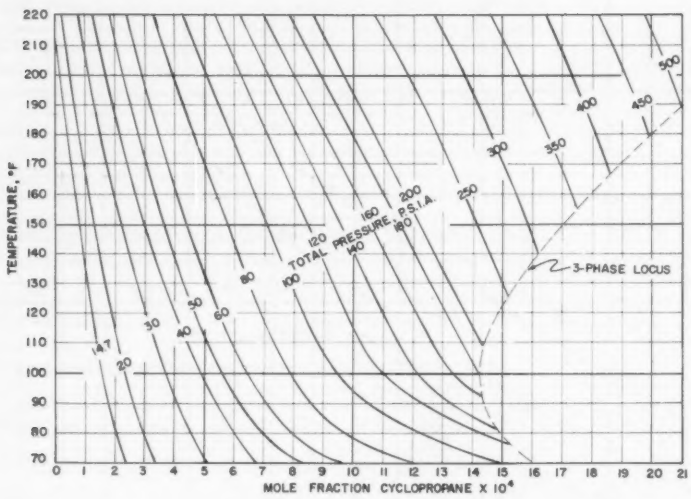

FIGURE 2—Temperature-composition diagram of water-rich phase.

TABLE 1—Experimental Data on Solubility of Cyclopropane in Water

Temperature °F	Total Pressure p.s.i.a.	Mole Fraction x 10^4
70	16.9	3.16
	23.9	4.17
	36.9	6.09
	46.9	7.64
	54.4	8.20
	71.9	10.32
	76.9	11.63
	101.7	14.70
100	17.0	1.95
	32.9	3.97
	42.9	4.96
	56.9	5.78
	76.4	7.28
	80.4	7.88
	92.9	8.32
	111.8	10.05
	170.8	13.85
160	19.9	1.51
	29.9	1.83
	46.9	3.04
	56.9	3.38
	67.9	5.01
	78.9	5.09
	87.9	6.07
	97.8	6.06
	139.8	9.07
	203.2	11.87
	307.4	16.03
	331.3	16.51
220	24.9	0.72
	35.9	1.24
	43.9	1.48
	51.9	1.89
	53.4	2.09
	63.4	2.64
	66.4	3.01
	87.4	3.67
	112.3	4.70
	117.8	4.93
	126.8	4.97
	141.7	5.69
	177.8	7.79
	281.7	11.19
	406.7	17.19
	619.9	24.00

TABLE 2—Smoothed Data in the Two Phase Region

(concentration of cyclopropane in water-rich liquid phase in mole fraction x 10^4)

Pressure p.s.i.a.	TEMPERATURE °R					
	70	100	130	160	190	220
14.7	2.35	1.55	1.08	0.70	0.30	a
20	3.32	2.35	1.69	1.15	0.65	0.22
30	5.05	3.73	2.76	1.91	1.30	0.78
40	6.70	4.89	3.68	2.70	1.91	1.27
50	8.22	5.59	4.30	3.30	2.50	1.83
60	9.60	6.48	5.10	4.06	3.17	2.42
80	12.15	7.91	6.49	5.40	4.30	3.29
100	14.80	9.47	7.92	6.71	5.48	4.23
120	....	11.01	9.38	8.03	6.68	5.34
140	....	12.19	10.57	9.11	7.62	6.14
160	....	13.34	11.65	10.10	8.55	6.99
180	....	14.22	12.66	11.06	9.48	7.88
200	....	....	13.31	11.76	10.22	8.72
250	....	....	15.02	13.78	12.32	10.74
300	....	....	....	15.45	14.18	12.75
350	....	....	....	17.33	16.04	14.60
400	....	....	....	....	17.81	16.42
450	....	....	....	....	19.51	18.20
500	....	....	....	....	20.96	19.78

a = above boiling temperature of liquid.

Inga

McKetta

Ruben F. Inga recently completed his M.S. degree in chemical engineering at The University of Texas and is now a process engineer with International Petroleum Company, Talara, Peru. He received his B.S. degree in chemical engineering from the University of San Marcos, Lima, Peru, and spent several years in industry before entering graduate school. Mr. Inga was a project engineer with the W. R. Grace & Co. in its Textile plant in Peru for two years. Later he was engineer for Cia. Industrias Nacionales S. A., Lima, and also with Stokes and Co., Ltd., Callao, Peru.

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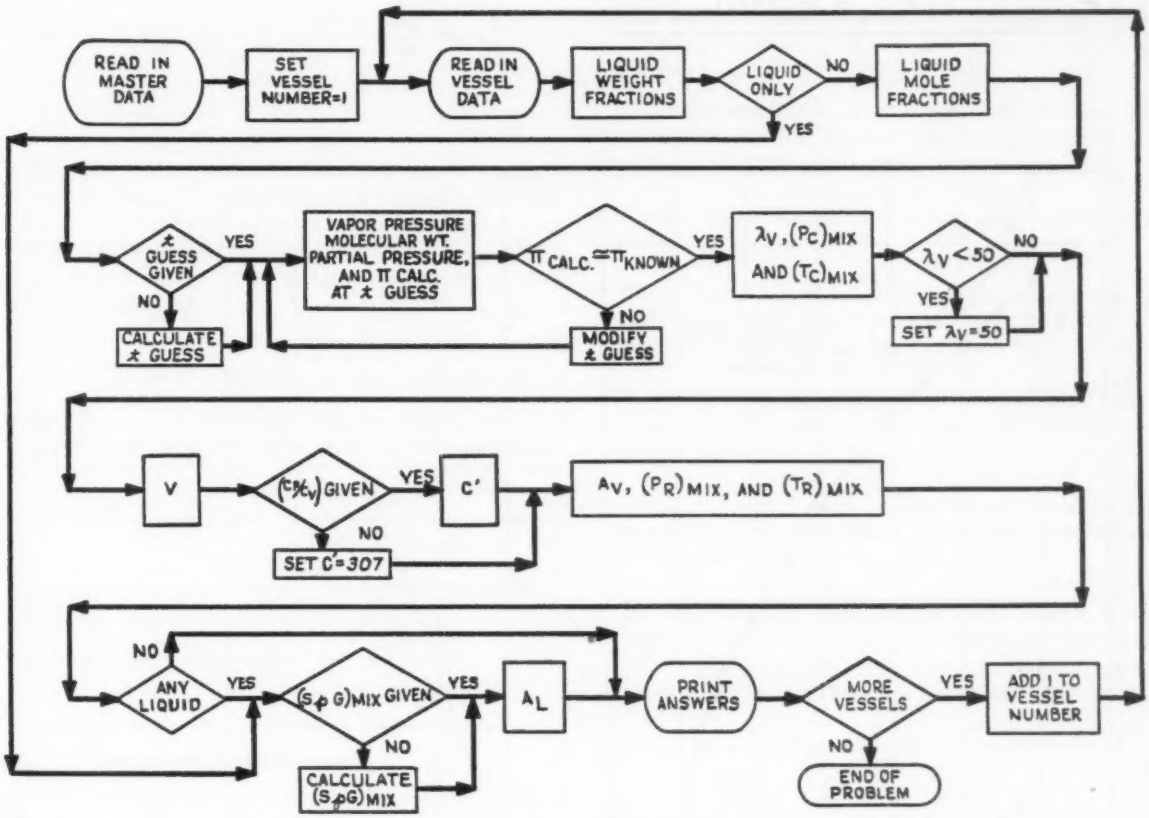

FIGURE 1—Abbreviated flow diagram of relief valve sizing program.

Use Computer to Size Relief Valves

Programing costs on a digital computer can be paid out after only 60 calculations

Moye Wicks, III, Phillips Petroleum Company, Bartlesville, Okla.*

THE REPETITIVE nature of relief valve calculations makes them highly suitable for processing on a digital computer. It is estimated that time spent for analysis, coding, and checking out the computer program can be paid out by only sixty valve sizings.

A general purpose routine is developed with three main points in mind. First, preparation of data by users should be kept to a minimum. Second, the program should be applicable to mixtures containing a large number of components, and to practically an unlimited number of vessels. Third, since absolute accuracy requirements are not high, physical and thermodynamic property correlations should be used where possible. Block diagrams are attached showing in detail the calculation procedure.

THE BASIC EQUATIONS

Practically all vessels are required by insurance company safety regulations to have safety or relief valves.

* Present address: University of Houston, Houston, Texas.

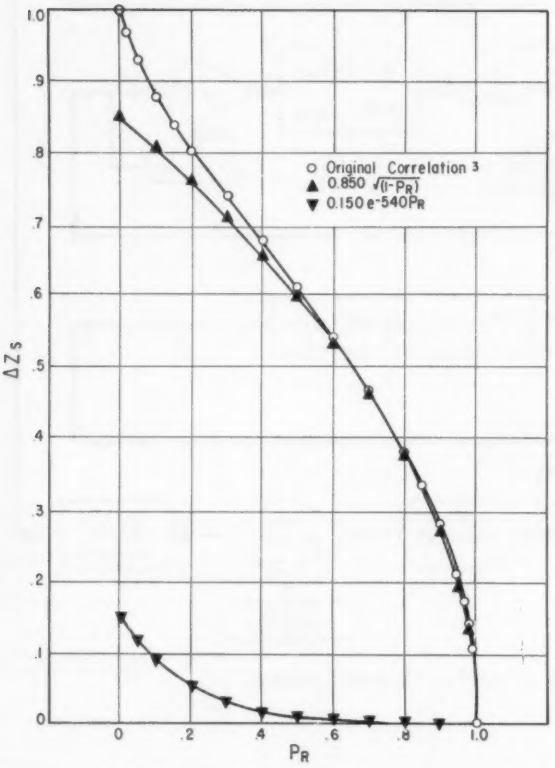

FIGURE 2—Difference of gas and liquid compressibility factors at saturation versus reduced pressure.

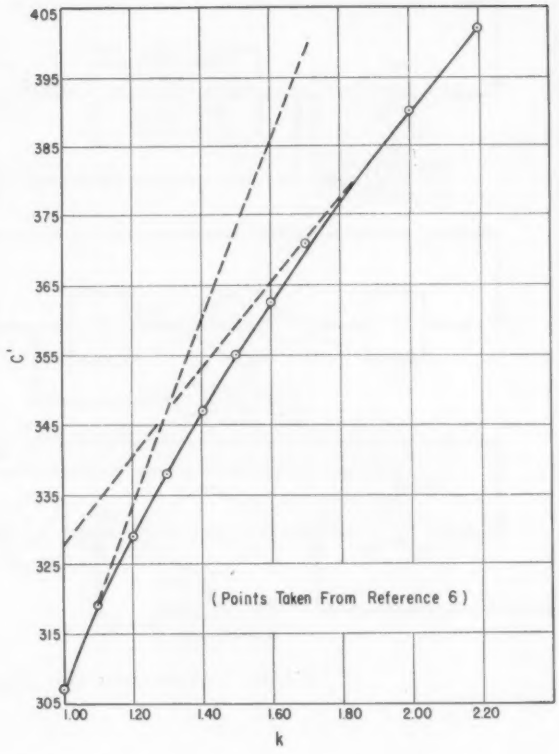

FIGURE 3—Nozzle gas constant versus specific heat ratio.

These valves and their associated piping are provided, among other reasons, to carry away explosive vapors which might be generated in case of a nearby fire and to prevent the internal pressure from building up beyond its maximum allowable level.

The most important variable in selecting a vapor relief valve is its flow area given by the equation:

$$A_V = \frac{V}{C'\pi}\sqrt{\frac{T_a z_V}{M_V}} \qquad (1)$$

where A_V is the valve flow area, Sq. In., required to relieve V
V is the vapor flow rate, lb/hr
C′ is the nozzle gas constant
π is the specified relieving pressure, psia (note that this is not the same as the "set" pressure)
T_a is the saturation temperature, °R, corresponding to π,
z_V is the vapor compressibility factor at π and T_a, and
M_V is the vapor molecular weight.

The vapor flow rate is calculated from the equation:

$$V = \frac{34{,}500\ (A_o)^{.82}F}{\lambda_V} \qquad (2)$$

where A_o is the outer surface area, sq. ft., of the vessel up to 25 ft. above grade or to the equator of a sphere, whichever is greater.
F is the "fireproofing credit" equal to 0.20 if the vessel is properly insulated, or equal to 1.00 if not,
and λ_V is the latent heat of vaporization of the vapor at relieving conditions, btu/lb.

The number 34,500 is the expected maximum heat flux due to fire.

The form of equation (2) is not rigorously correct for the unsteady-state case of batch vaporization from a vessel. Consideration of the first law of thermodynamics through the general equation

$$dE = dQ - dW_s + \sum_{J=1}^{J}\left(h_j + \frac{u_j^2}{2g_c} + D_j\right)dm_j$$

shows that (2) is true for this case only if the following conditions are fulfilled:

1. Height and velocity effects are negligible

2. Internal vessel pressure is essentially constant

3. $\left(h_L \frac{dm_L}{dt}\right) >> \left[m_L \frac{dh_L}{dt} + \frac{d}{dt}\left(m_G h_G\right)\right]$

4. $\frac{dm_G}{dt} << V$

Ordinarily, these restrictions are not severe, especially if the volatility of the vessel liquid is essentially constant. Moreover, the use of equation (2) is justified by the universally used maximum heat flux value, the approximate nature of the problem, and the equation's simplicity for field use.

Equation (2) breaks down near the critical "point" of the vapor mixture, where λ_V approaches zero. For this reason, a value of λ_V of less than 50 btu/lb is never used.

Although seemingly incongruous with absolute accuracy considerations, for the sake of consistency in the results a trial procedure is used to obtain λ_V:

- Assume vessel temperature at the specified relieving pressure.
- Using Raoult's law, calculate the partial pressure of each component from its vapor pressure at the assumed temperature and known liquid mole fraction.
- Using Dalton's law, calculate the total pressure corresponding to the assumed temperature by summing the partial pressures.
- If the calculated total pressure is not equal to the specified relieving pressure, re-assume temperature and repeat.
- Finally, knowing vessel temperature, obtain latent heats for each component in the mixture. Calculate λ_V by summing the pure component latent heats weighted according to each component's vapor weight fraction.

TABLE 1—Agreement of Equation (9) with the Correlation of Lydersen, et al, Over the Entire Range of Reduced Pressure

P_R	Equation (9) Δz_c	Reference 3 Δz_c	Difference %
0.00	1.000	1.000	0.0
0.05	0.943	0.930	+ 1.4
0.10	0.894	0.880	+ 1.6
0.20	0.811	0.802	+ 1.1
0.30	0.740	0.738	+ 0.3
0.40	0.675	0.677	— 0.3
0.50	0.612	0.612	0.0
0.60	0.544	0.542	+ 0.4
0.70	0.468	0.467	+ 0.2
0.80	0.382	0.382	0.0
0.90	0.270	0.280	— 3.7
0.95	0.191	0.210	—10.0
1.00	0.00	0.00	0.0

TABLE 2—Agreement of Equation (14) with Experimental Data on Specific Volume of Various Liquids

Compound	Z_c*	V_c* CC/GM MOLE	T_c °K*	T °K†	T_R	ρ_R	Eqn. (14) V CC/GM MOLE	Exp.† V CC/GM MOLE	DIFF. %
Methane	.290	99	190.7	111.6	.585	2.62	37.8	37.7	0.3
				143	.750	2.28	43.4	42.8	1.4
				183	.964	1.57	63.0	60.0	5.0
Propane	.277	200	369.9	293.6	.794	2.25	89.0	87.5	1.7
				358.6	.970	1.58	126	121	4.1
n-Heptane	.260	426	540.2	372	.689	2.64	162	162	0.0
				413	.765	2.44	175	175	0.0
				493	.913	1.94	220	216	1.8
Ethylene	.270	124	283.1	169	.598	2.75	45.1	49.4	8.7
				233	.824	2.20	66.4	60.7	9.4
Acetylene	.274	113	309.5	189	.611	2.69	42.0	42.0	0.0
				233	.754	2.37	47.7	47.1	1.3
				303	.979	1.52	74.4	75.3	1.2
Benzene	.274	260	562.6	373	.663	2.59	100.3	98.4	1.9
				423	.752	2.38	109	107	1.9
				543	.965	1.62	160	156	2.6
Fluoro-Benzene	.263	271	559.8	358	.640	2.72	99.7	102	2.3
				453	.809	2.30	118	120	1.7
Di-Methyl Ether	.285	178	400.1	249.4	.624	2.59	69.8	63.8	9.4
				293	.733	2.35	75.7	69.6	8.8
				393	.984	1.46	122	114	7.0
Ethyl Propylether	.265	339	500.6	334.5	.670	2.64	129	129	0.0
				373	.746	2.45	139	139	0.0
				493	.985	1.49	228	229	0.4
Methyl Formate	.255	172	487.2	305	.626	2.82	61.0	62.8	2.9
				353	.725	2.58	66.7	68.3	2.3
				483	.990	1.276	135	124	8.9
Carbon Tetrachloride	.272	276	556.4	350	.629	2.68	103	102	1.0
				423	.760	2.37	116	115	0.9
				543	.976	1.55	178	175	1.7
Ethyl Mercaptan	.274	207	499.0	307.5	.617	2.68	77.3	75.5	2.4
				353	.709	2.48	83.5	81.5	2.5
				483	.968	1.60	129	124	4.0
Chlorine	.276	124	417.0	238.5	.571	2.76	45.0	45.5	1.1
				253	.606	2.68	46.3	46.5	0.4
				383	.918	1.85	67.0	67.0	0.0

Maximum Deviation from experimental data 9.4%. /Average Deviation/ 2.75%. /Average Deviation without ethylene and dimethylether/ 1.96%.
*Reference 3. †Reference 7.

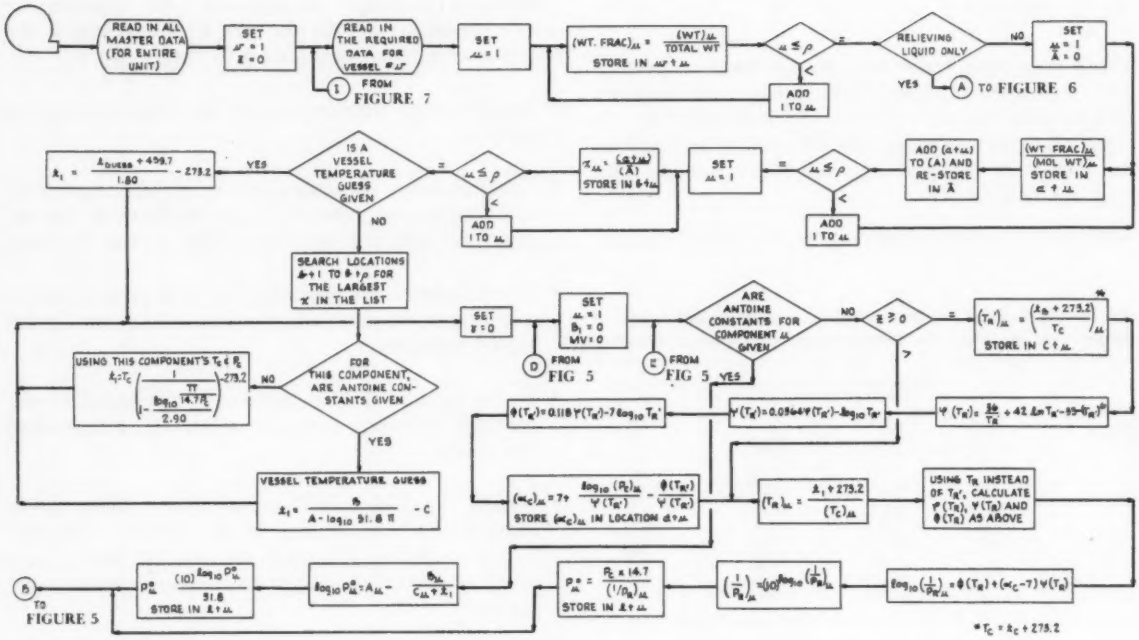

FIGURE 4

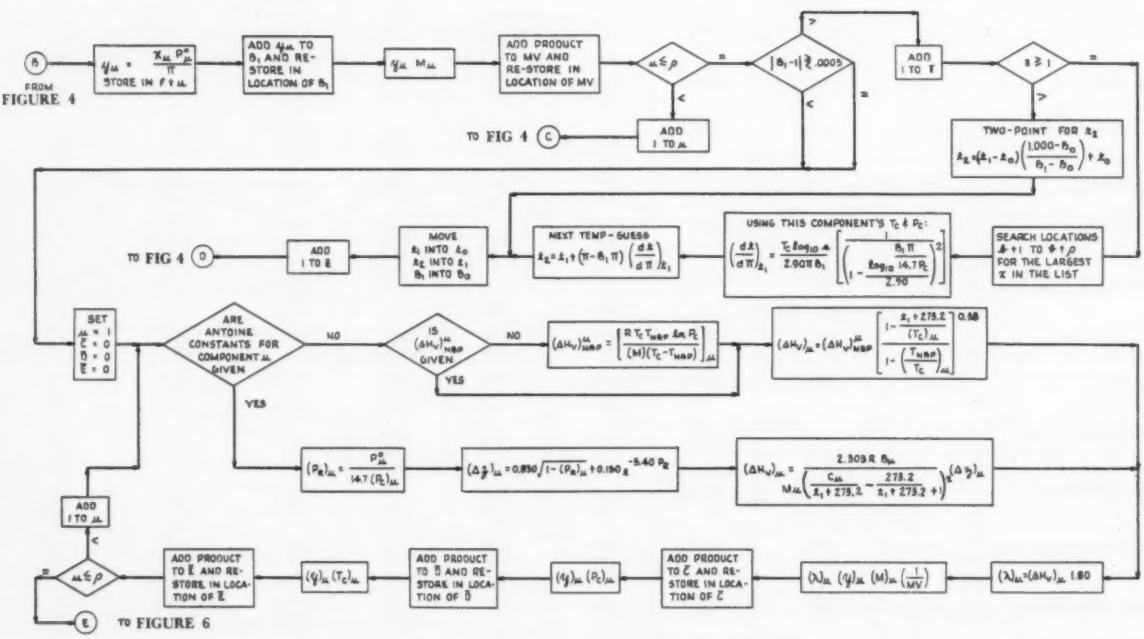
FROM FIGURE 4
STORE IN
ADD PRODUCT TO MV AND RE-STORE IN LOCATION OF MV
ADD 1 TO
TWO-POINT FOR
TO FIG 4 C
TO FIG 4 D
MOVE
NEXT TEMP-GUESS
USING THIS COMPONENT'S
SEARCH LOCATIONS
SET
ARE ANTOINE CONSTANTS FOR COMPONENT GIVEN
NO
IS GIVEN
YES
ADD PRODUCT TO E AND RE-STORE IN LOCATION OF E
ADD PRODUCT TO D AND RE-STORE IN LOCATION OF D
ADD PRODUCT TO C AND RE-STORE IN LOCATION OF C
TO FIGURE 6

FIGURE 5

FIGURES 4 through 7—Detailed block

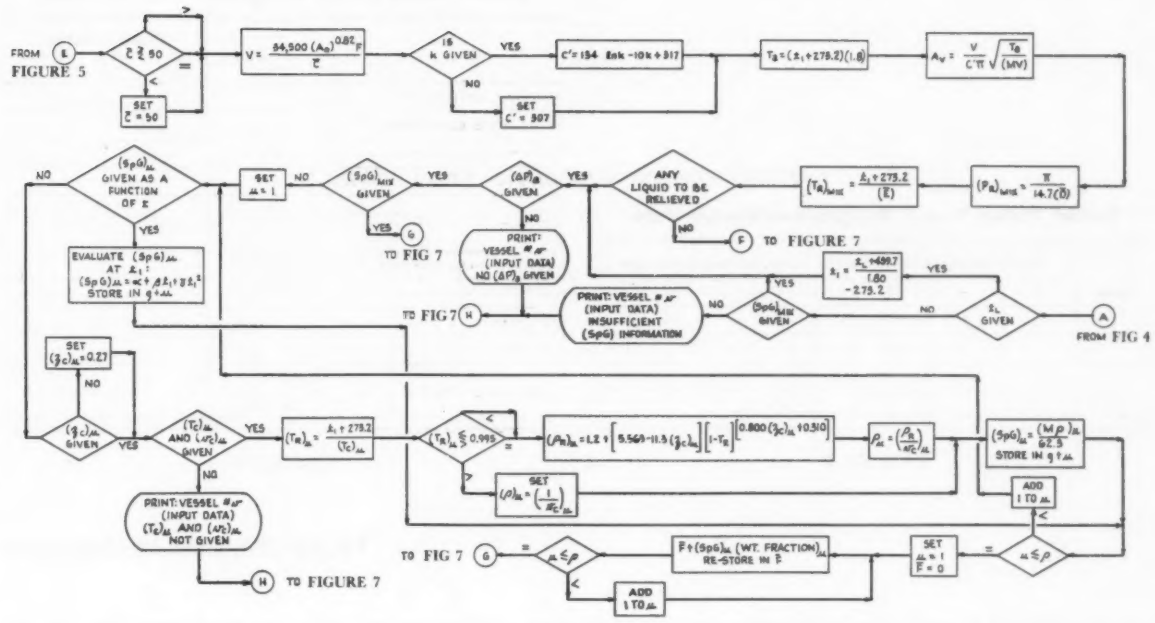
FROM FIGURE 5
SET Σ = 50
V = 84,500 (A_O)^0.82 / Σ
IS k GIVEN
YES
NO
C' = 134 Ln k − 10k + 317
SET C' = 307
T_R = (Σ_1 + 275.2)(1.8)
A_V = V / C'π √(T_R / (MV))
(Sp G)_M GIVEN AS A FUNCTION OF Σ
SET M = 1
(Sp G)_MIX GIVEN
(ΔP)_B GIVEN
ANY LIQUID TO BE RELIEVED
(T_R)_MIX = (Σ_1 + 275.2) / (Σ)
(P_B)_MIX = π / 14.7(D)
TO FIG 7
EVALUATE (Sp G)_M AT Σ_1 : (Sp G)_M = α + βΣ_1 + γΣ_1^2 STORE IN g + M
PRINT: VESSEL # (INPUT DATA) NO (ΔP)_B GIVEN
PRINT: VESSEL # (INPUT DATA) INSUFFICIENT (SpG) INFORMATION
(Sp G)_MIX GIVEN
Σ_1 = (Σ_1 + 459.7 / 1.80) − 275.2
Σ_L GIVEN
FROM FIG 4
SET (F_C)_M = 0.27
(F_C)_M GIVEN
(T_C)_M AND (ΔP_C)_M GIVEN
PRINT: VESSEL # (INPUT DATA) (T_C)_M AND (ΔP_C)_M NOT GIVEN
(T_R)_M = (Σ_1 + 273.2) / (T_C)_M
(T_R)_M ≷ 0.995
(ρ_R)_M = L.2 + [5.569 − 11.3 (F_C)_M] [1 − T_R] [0.800 (F_C)_M + 0.310]
ρ_M = (ρ_R / ΔP_C)_M
SET (ρ)_M = (1 / ΔP_C)_M
(Sp G)_M = (M ρ)_M / 62.3 STORE IN g + M
ADD 1 TO M
TO FIG 7
M ≤ ρ
F + (Sp G)_M (WT. FRACTION) RE-STORE IN F
ADD 1 TO M
SET M = 1 F = 0
M ≤ ρ

FIGURE 6

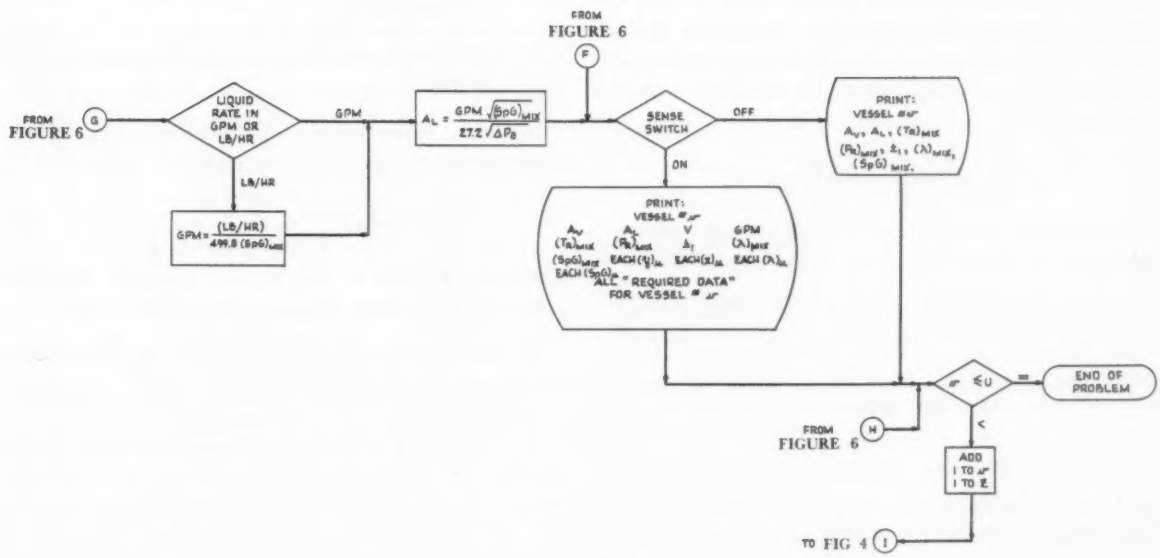
FROM FIGURE 6
FROM FIGURE 6
LIQUID RATE IN GPM OR LB/HR
GPM
LB/HR
GPM = (LB/HR) / 499.8 (Sp G)_MIX
A_L = GPM √(Sp G)_MIX / 27.2 √ΔP_B
SENSE SWITCH
OFF
ON
PRINT: VESSEL # A_V, A_L, (T_R)_MIX (P_B)_MIX, Σ_1, (λ)_MIX, (Sp G)_MIX.
PRINT: VESSEL # A_V (T_R)_MIX (Sp G)_MIX EACH (Sp G)_M A_L EACH (P_B)_M EACH (ψ)_M V EACH (Σ)_M GPM (λ)_MIX EACH (λ)_M "ALL" REQUIRED DATA" FOR VESSEL #
M ≤ U
END OF PROBLEM
FROM FIGURE 6
ADD 1 TO M 1 TO Σ
TO FIG 4

FIGURE 7

diagrams of relief valve sizing program.

Relief Valve Sizing Program—Vessel Data

Name	Liquid Composition, Weight Units, in Vessel Number												

FIGURE 8

Relief Valve Sizing Program—Vessel Data

	Vessel Number	
Relieving liquid only?		
Vessel temperature Guess,° F		
Relieving pressure, psia		
Ao, sq. ft.		
F		
k		
Any liquid to be relieved?		
t_{LIQ}, ° F		
$(Sp\ G)_{MIX}$		
ΔPa, psi		
Liquid rate to vessel given in GPM or Lb./Hr.		

FIGURE 9

FIGURES 8, 9 and 10—Input data

Use of NGAA K-values for bubble-point temperature was considered, but data preparation difficulties for the users and the approximate nature of equation (2) did not warrant such a refinement.

Besides relieving vapors, many times relief valves are specified for service with liquids. For example, a vessel designed for low-pressure storage may be downstream from a high-pressure source. If a valve closes on the vessel discharge, the internal pressure must be kept below its maximum allowable value by routing the incoming liquid through a properly designed relief valve to emergency storage. These valves are sized with the equation:

$$A_L = \frac{(gpm)}{27.2}\sqrt{\frac{(Sp.G)_{MIX}}{\Delta P_a}} \qquad (3)$$

where A_L is the valve flow area, sq. in., required to relieve (gpm)

(GPM) is the flow rate of liquid to be relieved, gal/min

$(Sp.G)_{MIX}$ is the liquid specific gravity at the vessel temperature

and ΔP_a is the differential set pressure, psi (set pressure minus back pressure).

For vapor relief valve calculations, the trial procedure to establish bubble point temperature was set up on the computer exactly as described in the above steps.

DATA CORRELATIONS AND CURVE-FITS

Vapor Pressure. As stated above, the vessel temperature is determined by trial using Raoult's and Dalton's laws. They can be expressed mathematically by the single equation:

$$\sum_{i=1}^{n} y_i = \sum_{i=1}^{n} \frac{x_i P_i}{\pi} = 1.00, \qquad (4)$$

where y_i is the vapor mole fraction of component i in equilibrium with x_i

x_i is the liquid mole fraction of component i

and P_i is the vapor pressure, psia, of i at the assumed temperature

In other words, temperature must be chosen so that (4) is satisfied.

If Antoine vapor pressure equation constants are available[1] the following equation is used:

$$\log_{10} P_i = A_i - \frac{B_i}{C_i + t} \qquad (5)$$

where A_i, B_i, and C_i are Antoine constants for component i, and t is the assumed temperature.

If Antoine constants are not available for a particular component, the Riedel[2] correlation is used:

$$\log\left(\frac{1}{P_r}\right)_i = \Phi\,(T_R)_i + (\alpha_c - 7)\,\Psi\,(T_R)_i \qquad (6)$$

where $\Phi\,(T_R)_i = 0.118\,\omega\,(T_R)_i - 7\log_{10} T_{Ri}$

$\Psi\,(T_R)_i = 0.0364\,\omega\,(T_R)_i - \log_{10} T_{Ri}$

$$\omega\,(T_R)_i = \frac{36}{T_{Ri}} + 42\ln_e T_{Ri} - 35 - (T_R)^6{}_i$$

P_{Ri} is the reduced vapor pressure of i at reduced temperature T_R, and α_c is a constant determined by sub-

Relief Valve Sizing Program—Master Data

NAME	Molecular Weight	Antoine Constants A	B	C	t_c °C	P_c ATM	V_c Ft.³/Lb-Mol	Z_c	t_{NPB} °C	Δh^{NBP} Cal/Gram	Specific Gravity α	β	γ

FIGURE 10

sheets for valve sizing program.

stitution of a known P_R and T_R, such as the normal boiling point, into (6).

Latent Heat of Vaporization. Use of equation (2) requires that the mixture latent heat be known. As with all mixture properties used here, the property change on mixing is ignored, and λ_V is calculatd from the equation:

$$\lambda_v = \Sigma_{i=1}^{n} y'_i \lambda_i \tag{7}$$

where y'_i is the vapor weight fraction, and λ_i is the latent heat of pure i at the mixture temperature, btu/lb. Knowing vapor composition, each y_i is available, and with saturation temperature from the trial calculation, each λ_i can be determined:

If Antoine constants are available for component i:

$$\lambda_i = \frac{4.145\, R\, B_i}{\left(\frac{C_i}{T} - \frac{273.2}{T} + 1\right)^2 M_i} (\Delta Z_g)_i \tag{8}$$

where R is the gas constant $= 1.987 \frac{\text{cal}}{\text{gm mol °k}}$

M_i is molecular weight of i

T is the absolute temperature, °K

and $(\Delta Z_g)_i$ is the difference between gas and liquid compressibility factors at saturation for component i.

Equation (8) was obtained by combining (5) with the Clausius-Clapyeron equation.

It has been found[3] that ΔZ_g depends only on the reduced pressure for all compounds, independent of their critical compressibility factor. The correlation presented by these authors is shown in Figure 2; also shown are two curves which were added together to give an equation for the correlating line. Agreement of this equation

$$(\Delta Z_g)_i = 0.850 \sqrt{(1 - P_R)_i} + 0.150\, e^{-(5.10)P_{Ri}} \tag{9}$$

with the original correlation is shown in Table 1.

If Antoine constants are not available for component i, the Watson[4] correlation,

$$(\lambda_i)T_R = (\lambda_i)T_{R1}\left[\frac{1 - T_R}{1 - T_{R1}}\right]^{0.38} \tag{10}$$

is used, knowing λ_i at one given temperature, T_{R1}, such as the normal boiling point. If λ_i at the normal boiling point is not known it is estimated by the Giacalone[5] equation:

$$(\lambda_i)_{NBP} = \frac{1.80\, R(T_c\, T_{NBP} \ln P_c)_i}{M_i(T_c - T_{NBP})_i} \tag{11}$$

knowing only critical properties and normal boiling temperature.

Specific Gravity. As indicated by equation (3), to size relief valves for liquid service, the liquid specific gravity must be known. If $(Sp.G)_{MIX}$ is not given, provision has been made to calculate it internally from critical data on each component. The mixture specific gravity is obtained as follows:

$$(Sp.G)_{MIX} = \Sigma_{i=1}^{n} = x_i' (Sp.\ G)_i, \tag{12}$$

where x'_i is the liquid weight fraction of i and $(Sp.G)_i$ is the specific gravity of pure i at the vessel temperature.

The Lydersen, et al correlation[3] of reduced density versus reduced temperature and critical compressibility factor is used to calculate $(Sp.G)_i$. In the course of curve-fitting the tabulated correlating data, it was found that log $(\rho_R - 1.20)$ plotted versus log $(1 - T_R)$ gave

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relatively good straight lines up to values of T_R of about 0.99, for compounds with critical compressibility factors in the range 0.25 to 0.29, inclusive. About 80 percent of all common compounds have z_c within this interval. For a given z_c, the equation took the form

$$\rho_R = 1.20 + a(1 - T_R)^b \qquad (13)$$

The constants a and b obtained for each z_c were found to be nearly linearly related. Fitting a and b with straight-line functions of z_c gave a final correlation equation for ρ_R:

$$\rho_R = 1.20 + [5.563 - 11.03\, z_c]\,[1 - T_R]\,(0.800\, z_c + 0.310) \qquad (14)$$

A comparison of calculated and *experimental* specific volumes (reciprocal density) is shown in Table 2. The absolute value of the average deviations is 2.75 percent; since the original correlation is accurate to 2.8 percent,[3] equation (14) is acceptable.

Nozzle Gas Constant. To obtain A_V, according to equation (1) the nozzle gas constant C′ is required. C′ is given as a function of C_P/C_V, or k, in reference 6. Figure 1 is a plot of these data points. The dashed lines on each end of the curve show how its slope changes as k increases from 1.00 to 2.20. Notice that the slope decreases as k increases.

TABLE 3—Agreement of Equation (17) with Nozzle Gas Constant Data from Reference (6)

K	Equation (17) C′	Reference 6 C′	Difference %
1.00	307	307	0.00
1.10	319	319	0.00
1.20	329	329	0.00
1.30	339	338	0.30
1.40	348	347	0.29
1.50	356	355	0.28
1.60	364	363	0.28
1.70	371	371	0.00
2.00	390	390	0.00
2.20	401	402	0.25

In order to derive an equation for this curve, it was observed that the slope, $\frac{d\,C'}{d\,k}$, is nearly inversely proportional to k. In other words, m in the equation

$$\frac{d\,C'}{d\,k} = \frac{m}{k} \qquad (15)$$

is almost constant, having a value of 133 at k = 1.00 and 136 at k = 2.20. Choosing m = 134, and integrating (15), the resulting approximate equation for C′ is:

$$C' = 134 \ln k + 307 \qquad (16)$$

The differences between (C′)'s calculated from (16) and tabulated (C′)'s were linear functions of k, which when added on to (16) gave the final correlating equation:

$$C' = 134 \ln k - 10\, k + 317. \qquad (17)$$

Agreement between calculated and tabulated (C′)'s is shown in Table 3. All deviations are less than or equal to 0.30 percent.

Figure 1 shows the entire calculation procedure in abbreviated form. Each block may represent several calculation steps as compared with the detailed block diagrams, Figures 4, 5, 6 and 7.

The program input data is organized into two groups: master data, including information about each component to be found in vessels throughout the entire unit, and vessel data, including the necessary information on each vessel. A sample set of input data sheets is shown in Figures 8, 9 and 10.

ACKNOWLEDGMENT

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How Well Can You Rely on Lab Tests?

To know how close to specification limits you can safely blend your products, you need to know the reliability of the laboratory tests. Here is a way to evaluate these analyses

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TO MAXIMIZE PRODUCTION, a refiner usually tries to blend as close as possible to specification limits. This can be risky business. It increases the chances of having a blend rejected for being off specification. However, a method is proposed here which will give confidence and peace of mind to the man certifying the quality of the borderline blends.

The certifier can adopt one of two approaches:

- The time honored method whereby any results within the limit is accepted, no matter how close to it. Any initial result outside the limit is repeated, and if the second result is satisfactory, which may be due to conscious or unconscious bias by the tester, then an intuitive decision is made whether to continue testing or to reject the first result and so on.

- The confidence limits for test results can be determined quantitatively and a margin can be set wherein repeat tests must be done to ensure that the mean result meets the specification with a known degree of confidence.

The second method is preferred by the refiner who wants to strengthen confidence in the quality of his products. This is particularly true for aviation fuels where human lives depend on correct quality.

Table 1—Testing Limits Resulting from Precision Monitoring Program

Test	Method No.	Lab.[1]	No. of Check Results	95 Percent Confidence Limits of a Single Result
Specific Gravity	ASTM D 1298/55			
Gasoline		A	101	±0.0009[2]
Gasoline		B	60	±0.0009[3]
Gas Oil		A	101	±0.0018[2]
Gas Oil and Diesel		B	60	±0.0005[3]
Fuel Oil		B	60	±0.0024[3]
Fuel Oil and Residue		A	99	±0.0061[2]
Distillation	ASTM D 86/56			
50% Evap. (Motor Gasoline)		B	62	±1.6 °C
95% Rec'd. (Lt. Ck'd Spirit)		A	37	±4 °C
95% Rec'd (Hy. Ck'd Spirit)		A	47	±3.5 °C
Viscosity, Redwood I (Fuel Oil)	IP 70/57			
170–200 sec. Range		A	40	±3.4 sec.
250–350 sec. Range		A	43	±14.0 sec.
Viscosity, Kinematic (Fuel Oil)	ASTM D 445/53			
<50 cS		B	13	±0.33 cS
50–80 cS Range		B	60	±0.8 cS
85–225 cS Range		B	8	±3.9 cS
Flash Point				
Abel (90–115 °F Range)	IP 170/59	A	96	±2 °F
Abel	IP 170	B	60	±2 °F
PM Closed (144–220 °F Range)	ASTM D 93/58	A	103	±6 °F
Pour Point	ASTM D 97/57	B	79	±10 °F
Temp. at Vapor/Liquid Ratio.	BP 97[5]			
16/1		B	60	±1.0 °C
36/1		B	60	±1.0 °C
Bitumen Penetration	IP 49/58			
80/100 Grade		A	42	±2 mm/10
180/200 Grade		A	62	±8 mm/10
Aniline Point	ASTM D 611/55			
White Oil		B	50	±0.3 °C
Black Oil		B	50	±0.6 °C
Hydrocarbon Type (Liquid Products)	ASTM D 1319	B	60	±0.9%
Tetraethyl lead (gasoline)	ASTM D 526/56	B	101	±0.07 ml/IG
Mercaptan Sulfur				
Solutized St. Run Benzene	IP 104/53	A	87	±0.0034 wt %
Solutizer Solution	SMS 304[6]	A	68	±0.032 wt %[4]
Sulfur X-Ray (fuel Oil)	BP[7]	A	90	±0.10%
Sulfur, Lamp Gravimetric (Lt. Oil)	ASTM D 1266/57T	C	30	±0.016 wt%
Sulfur, Bomb	ASTM D 129/58			
Fuel Oil		C	51	±0.14 wt%
Gas Oil and Diesel		C	32	±0.074 wt %

[1] Three different laboratories were used in this program. They are denoted by: A—Works control lab., B—Shipping lab., and C—Sulfur lab.
[2] Type 505 hydrometer used.
[3] L.50 Type 1 hydrometer used.
[4] Data for first program run in August–November, 1959. Second program in March–June, 1960, show limits increased to ±0.07 wt. % because of higher total mercaptan sulfur level and a 50% change in testers.
[5] Anal. Chem. 1956, **28**, 99.
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Confidence Limits for Some Tests. Standard test methods developed by the American Society for Testing Materials (ASTM) and the Institute of Petroleum (IP) usually indicate their repeatability and reproducibility. However, these data in many cases have not been obtained by statistical analysis of inter-laboratory results. Also, although test procedures and equipment are standardized, and the tester receives initial training, there is no guarantee that every tester will work to the standard confidence limits. Therefore, it is necessary for each laboratory to determine its own precision for each test and to maintain a continuous program which will cope with changes in staff, test methods and modernization of equipment.

Since April 1959, the BP Refinery (Kwinana) Ltd. in Western Australia has used a "precision monitoring" program to determine confidence limits of tests made at its three local laboratories. The results are given in Table 1. It should be noted that these results do not give test "repeatability" or "reproducibility" as defined by ASTM/IP. However, the probable maximum difference between two operators may be estimated as $(\sqrt{2})$

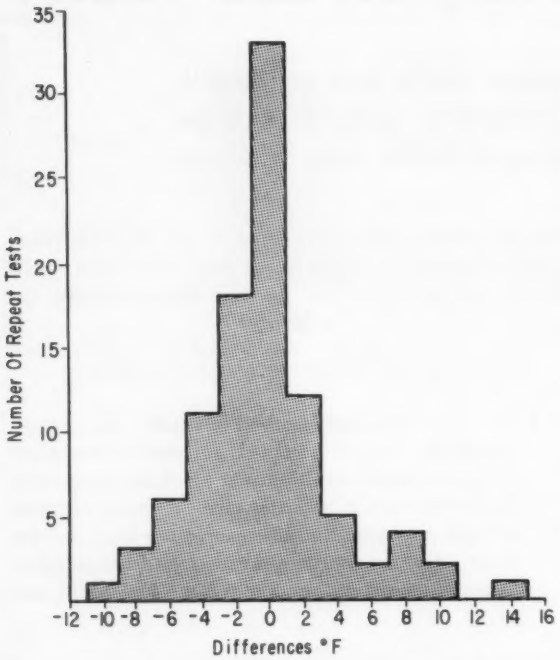

FIGURE 1—As each sample is retested, the difference between the second and first analyses is plotted on a histogram. Here is a plot for the Pensky-Martens flash point analyses.

(95% confidence limits), and this will fall between repeatability and reproducibility conditions.

By July 1960, it was possible to introduce formally a "sequential testing" system, using the precision monitoring data. Tests are automatically repeated on the same sample by another operator if the first result is within a certain margin from the specification limit. If the mean of the first two results is unsatisfactory, the matter is discussed with the man formulating the blends and a decision is made either to retest a fresh sample or to correct the blend. Generally, not more than three tests are done before a positive decision is made for acceptance or rejection of the material. It is assumed here that the supplier has to show only that his test results are within the specification limits; he does not guarantee that a consumer's test results will meet the same limits.

The confidence limits are narrowed with retesting by a factor of $\frac{1}{\sqrt{n}}$; i.e. if confidence limits are $\pm$ 4 for a single test, for the mean of two tests they will be $\frac{\pm 4}{\sqrt{2}}$.

Margins are not always set exactly at confidence limits, but may be narrowed or increased depending on previous control testing of components in each finished product. For example, if it takes six days to fill a tank and the stream entering that tank is tested daily for a given specification point, a higher degree of confidence can be placed in the over-all result on the finished tank than the formal confidence limits of a single test.

How Precision Monitoring Works. This program utilizes routine daily samples and tests, and thus avoids any bias which spoils artificially imposed factorial design techniques. It has been found impossible to prevent testers from knowing that a factorial design experiment is under way, and that they are replicate testing the same sample. It is then common for them to "write in" the results. For the methods under study, all routine samples are retained by the laboratory supervisor. When there are sufficient similar samples to ensure that any one cannot be identified by its properties, samples are relabeled and handed back to the original tester or to any other tester in that group. Thus, the group or laboratory error is established. This type of investigation is more acceptable to the tester than one which determines and publishes his individual errors.

As an arbitrary rule, repeat samples should not be more than a week old to avoid ageing effects. For some tests, e.g. hydrocarbon type composition of a non-volatile sample, it is not necessary to apply this ruling. A balance must be struck between avoiding ageing effects and accumulating enough samples to avoid identification by the tester. The repeat sample volume is just enough for one determination.

Care has to be taken that original tests are distributed over all testers and not done by one or two men who might prefer that test.

Only three test methods are examined at one time. An arbitrary minimum of 60 retests has been set, so that the statistical analysis is of high validity. An examination of three methods is completed in two to three months, the precision monitoring work being in the range 1 to 3 percent of the total testing load. The load on the supervisor is higher—about 5 percent of his time. Even at this level, testers and first-line supervisors need considerable "education" before precision monitoring samples are accepted as having equal priority with production samples. Where the work load is finely balanced against the man hours available it may be necessary to work some overtime to keep the monitoring program on the move.

An alternative technique of examining a large number of methods concurrently has been tried. It has the disadvantage that the time taken to obtain sufficient results for a valid analysis is so long that interim changes in staff, methods or equipment render valueless the calculated confidence limits in a refinery. The aim of precision monitoring is to determine current confidence limits, and intensive programs which gave the answers in a few weeks would be preferred but would be costly in manhours.

It is not necessary to examine in detail all tests done in the laboratory. A specification for one product with ten points may have only three which are limiting properties, and one, two or three of these may also be critical points in other product specifications. "Limiting properties" refers to those points which are usually close to the specification limits, and where the test confidence limits may be equal to or greater than the difference between the test result and the specification

limit. In all, the tests requiring precision monitoring immediately are certainly less than half the total number done in the laboratory.

Results are plotted in the form of histograms which are displayed prominently in each Laboratory. An example is given in Figure 1. This enables testers to follow the progress of each program, and it has been observed that the precision of each test method improves as its program proceeds. In plotting, the first result is taken always as the reference i.e. if the second of a pair result is higher than the first then the difference is positive, and vice versa. Differences are plotted on the horizontal scale and frequency on the vertical scale. The chart shows both positive and negative differences. The ASTM[4] recommends that cell boundaries be chosen half way between two possible observations, and that the number of cells should be between 13 and 20. A "cell" is a group of differences plotted vertically at the same position on the horizontal axis. If differences were recorded to 1° F, then cell boundaries would be at 0.5° F.

Rejection of results has always been a difficult problem in experimental work which is to be analyzed statistically. The Kwinana method is:

> If the difference between initial and repeat tests is abnormal, the repeat sample is checked to ensure that its properties did not change due to contamination or maltreatment. If the sample was good, the results are included in the survey though there may be large tester errors and the cause of these is known e.g. misreading a stopwatch. Such results should not be rejected, because they can recur in normal testing.

Handling of samples, plotting of results and statistical analysis are all done by individual laboratory supervisors. The functions of precision monitoring and training/retraining should be closely related. The "trainer" assists the supervisors with the physical work, and he is particularly useful for between-laboratory comparisons.

How To Do The Statistical Analysis. The procedure for statistical analysis of results is given here in a form suitable for calculation by men who have little knowledge of statistical mathematics. The data to be analyzed are somewhat unusual, in that the estimate of laboratory precision is based on differences between one operator's result and a second operator's result on a series of samples of different true mean value. It is assumed that all error distributions are normal, and are double tailed. The first step is to determine whether there is a significant systematic error between the first and second results, e.g., bitumen hardening after reheating would cause a systematic error. The "t" test is used to determine whether the mean of the differences differs significantly from the expected value of zero. If, at the 95-percent level, there is no significant difference between the first and second observations, the "total error" is calculated in accordance with ASTM procedure. However, in some cases it is not possible to conduct a program without obtaining a significant systematic error. In these cases the "operator error" is calculated separately. "Total error" includes all possible sources of error, whereas "operator error" includes the systematic error, if any.

A standard table is constructed for the results. Signs are taken into account in the differences column. An example is shown in Table 2 for the results obtained in the Works Control Laboratory for penetration of

Table 2—Example Analysis

Pair No.	First Result = X_1, X_3	Second Result = X_2, X_4	Differences (+ OR —) = d	(Differences)^2 = d^2
1	5	7	+ 2	4
2	31	27	— 4	16
3	37	35	— 2	4
4	36	34	— 2	4
5	35	39	+ 4	16
6	36	39	+ 3	9
7	44	43	— 1	1
8	55	54	— 1	1
9	17	17	0	0
10	59	66	+ 7	49
11	66	67	+ 1	1
12	30	32	+ 2	4
13	52	48	— 4	16
14	37	43	+ 6	36
15	44	47	+ 3	9
16	63	47	—16	256
17	48	50	+ 2	4
18	39	30	— 9	81
19	64	50	—14	196
20	43	37	— 6	36
21	47	44	— 3	9
22	63	47	—16	256
23	48	50	+ 2	4
24	54	49	— 5	25
25	31	27	— 4	16
26	41	48	+ 7	49
27	68	62	— 6	36
28	54	44	—10	100
29	35	35	0	0
30	31	34	+ 3	9
31	31	37	+ 6	36
32	35	35	0	0
33	32	31	— 1	1
34	32	31	— 1	1
35	23	23	0	0
36	30	32	+ 2	4
37	18	20	+ 2	4
38	47	40	— 7	49
39	27	29	+ 2	4
40	44	40	— 4	16
41	41	46	+ 5	25
42	37	36	— 1	1
43	37	39	+ 2	4
44	48	44	— 4	16
45	62	60	— 2	4
46	72	67	— 5	25
47	67	63	— 3	9
48	39	33	— 6	36
49	37	33	— 4	16
50	37	34	— 3	9
51	37	33	— 4	16
52	37	33	— 4	16
53	37	30	— 7	49
54	62	48	—14	196
55	63	46	—17	289
56	59	47	—12	144
57	58	43	—15	225
58	42	42	0	0
59	55	45	—10	100
60	18	21	+ 3	9
61	41	38	— 3	9
62	50	44	— 6	36
m = 62			Σd = —172	Σd^2 = 2596

180/200-grade bitumen. For simplification of the table, 150 has been subtracted from every result.

The symbols used in the calculations are:

$$m = \text{Number of pairs}$$
$$d_1, d_2 \ldots d_m = \text{Differences between pairs}$$
$$\sigma_I = \text{Operator error standard deviation} = \sqrt{\left[\frac{1}{2(m-1)}\right]\left[\Sigma d^2 - \frac{(\Sigma d)^2}{m}\right]}$$
$$\sigma_L = \text{Total error standard deviation} = \sqrt{\frac{\Sigma d^2}{2m}}$$

For any given set of results, t is calculated by:

$$t = \left| \frac{\Sigma d}{\sigma_I \sqrt{2m}} \right|$$

Also read the value of t from a standard table of t at $(m-1)$ degrees of freedom and the 95 percent probability level. Then if the calculated value is less than the value read from the tables, there is no significant difference between the first set of results and the second set of results; i.e., there is no systematic error. In this case, calculate the standard deviation of a single result from the equation for σ_L. The 95-percent confidence limits for a single result is equal to $\pm(\sigma_L \times t)$, where t is read from tables at the 95-percent probability level and m degrees of freedom.

If the calculated value of t is greater than the value read from the tables, there is a significant difference between the first set of results and the second set of results, i.e., there is a systematic error. The 95-percent confidence limits of a single result are then $\pm (\sigma_I \times t)$ where t is read from the tables at the 95-percent probability level and $(m-1)$ degrees of freedom.

For the example given in Table 2, the t test is applied as follows:

$$m = 62$$
$$\Sigma d = -172$$
$$\Sigma d^2 = 2596$$

$$\sigma_I = \sqrt{\left[\frac{1}{2(m-1)}\right]\left[\Sigma d^2 - \frac{(\Sigma d)^2}{m}\right]}$$
$$= \sqrt{\left[\frac{1}{2(62-1)}\right]\left[2596 - \frac{(-172)^2}{62}\right]}$$
$$= 4.17$$
$$t = \left| \frac{\Sigma d}{\sigma_I \sqrt{2m}} \right|$$
$$= \left| \frac{-172}{4.17\sqrt{2(62)}} \right|$$
$$= 3.71$$

From tables, t (95 percent level, $\phi = m-1$) = 2.00. There is a significant difference since the calculated t is greater than the t from the standard tables.

$$\text{The 95\% Confidence limits} = \pm (\sigma_I \times t)$$
$$= \pm (4.17 \times 2.00)$$
$$= \pm 8$$

This is one of the values reported in Table 1.

For tests such as pour point where results are, in effect, rounded off in 5° intervals, the confidence limits are also rounded off in 5° intervals. For example, confidence limits of ± 7° F would be reported as ± 10° F (effective).

ACKNOWLEDGMENT

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How Newest Helium Plant Is Working

The three crude helium separation units at Keyes helium plant.

From first nine months of operation, the Bureau of Mines plant at Keyes, Oklahoma, shows 91 percent helium recovery and helium cost of $9.11/Mcf

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THE NEWEST HELIUM PLANT built by the U.S. Bureau of Mines is now operating at 91 percent helium recovery. Helium cost is $9.11 per thousand cubic feet, according to the latest government report.[1] While the basic process scheme is the same as the other four Bureau of Mines plants use, the new plant includes a number of process and equipment improvements.

The Keyes helium plant was constructed under an expedited schedule to supply the urgent and growing demand for helium in atomic energy, missiles, aerology, space exploration, shielded-arc welding and low-temperature research. Construction was started in December 1958 and completed in August 1959.

The plant, near Keyes, Okla., processes 2 percent helium-bearing natural gas from the Keyes gas field. During fiscal year 1960 the plant produced and shipped 263 million cubic feet of helium, equivalent to an annual rate of 290 million cubic feet. Production cost was $9.11 a thousand cubic feet of helium.

A low-temperature process involving two steps is used; the first separates a crude helium product from the natural gas at about —250° F and 225 psig; and the second purifies the crude helium to a high-purity product (Grade-A helium, 99.995 percent helium) at about —320° F and 2750 psig.

Grade-A helium is shipped in specially constructed railway tank cars at pressures ranging from 2,100 to 3,675 psig.

Plant Description. Helium production at the Keyes plant follows the basic processing steps used at the other Bureau plants. Basically, the steps involved are (1) gas treating, (2) crude-helium separation and (3) final purification. General processing steps and auxiliary services are shown schematically in Figure 1; details are outlined in last section.

Plant Performance. The Keyes plant has a natural gas processing capacity of 70 million cubic feet a day at a pressure of 450 psig. Average gas compositions of the inlet and outlet gas are shown in Table 1. General plant performance for Fiscal Year 1960 is shown in Table 2. Performance during the startup period in August and September has been excluded.

Cost of Helium Production. During fiscal year 1960 the Keyes plant operated approximately 330 days (start-up August 2, 1959) and produced 263 million cubic feet of helium at an average cost of $9.11 a thousand cubic feet. A breakdown of the unit cost is shown in Table 3.

TABLE 1.—Average Gas Composition.

Component	Volume percent	
	Inlet gas	Outlet gas
Methane	64.2	66.7
Ethane	3.1	3.3
Propane	1.9	2.0
n-Butane	0.6	0.7
i-Butane	0.4	0.4
n-Pentane	0.2	0.2
i-Pentane	0.2	0.2
Cyclopentane	...[1]	...[1]
Hexanes plus	0.2	0.2
Nitrogen	26.2	26.1
Argon	0.1	0.1
Hydrogen	...[1]	...
Hydrogen sulfide	...	...
Carbon dioxide	0.8	...
Helium	2.1	0.13
Btu (calculated)	817	850[2]

[1] Less than 0.05 percent.

[2] The Btu improvement indicated above is the maximum expected. Btu improvement to date has been about 30 Btu.

Note: Fuel gas is obtained from the outlet gas stream.

How Newest Helium Plant Is Working...

TABLE 2.—Plant Performance for Fiscal Year 1960.

	Monthly average October-June[1]
Inlet gas pressure	454 psig
Outlet gas pressure	467 psig
Separation pressure	225 psig
Total inlet gas flow (14.65 psia and 60° F)	1,388,954 Mcf
Plant shrinkage (percent of inlet):	
Fuel	4.95
Extraction and losses	3.86
Total shrinkage	8.81
Plant fuel gas, (14.65 psia and 60° F)	67,586 Mcf
Helium content inlet gas	2.065%
Helium content residue gas	0.134%
Separation efficiency	93.78 %
Recovery efficiency	91.02 %
Salable helium recovered (14.7 psia and 70° F)	26,353 Mcf
Crude helium purity	60 to 80%

[1] Startup period of August and September excluded.

TABLE 3—Operating Cost of Keyes Helium Plant[1]
(August 17, 1959 to June 30, 1960)

Item		Dollars
Natural gas costs:		
Gas processing fee[2]		$ 584,659
Shrinkage cost due to removal of carbon dioxide, water, nitrogen, and helium[3]		138,199
Fuel cost[3]		182,154
Subtotal		$ 905,012
Plant operation:		
Labor	264,561	
Materials, supplies, etc.	143,502	
Subtotal		408,063
Plant maintenance:		
Labor	121,730	
Materials, supplies, etc.	57,827	
Subtotal		179,557
Depreciation (for 10 months):		
Plant (20 years)	448,801	
Camp (20 years)	12,710	
Subtotal		461,511
Plant administration:		
Supervision (salaries, materials, and supplies)	42,265	
Security and civil defense (salaries, materials, and supplies)	29,235	
Subtotal		71,500
Total direct operating cost		2,025,643
Unit cost of helium produced (direct operating cost)		7.71 per Mcf
Tank cars (104 cars required to ship output):		
Maintenance and testing	$ 69,748	
Depreciation (40 years)	163,534	
Subtotal		$ 233,282
General administrative overhead		133,477
Total of all costs		2,392,402
Unit cost of helium produced (all costs)		9.11 Mcf

[1] Total investment, $11,005.390; total helium produced, 262,672,000 cubic feet.

[2] A gas processing fee is paid the company as provided by contract. The fee covers ". . . gas processing and helium extraction rights and for providing gas deliveries at suitable pressure, volume and helium content, and for the helium extracted . . ." The fee is determined on the basis of ". . . 4 cents per thousand cubic feet for gas (processed) having a weighted average helium content of 2.0 percent during the billing period."

[3] Shrinkage and fuel cost at 26 cents a thousand cubic feet.

Details on the Process Flow

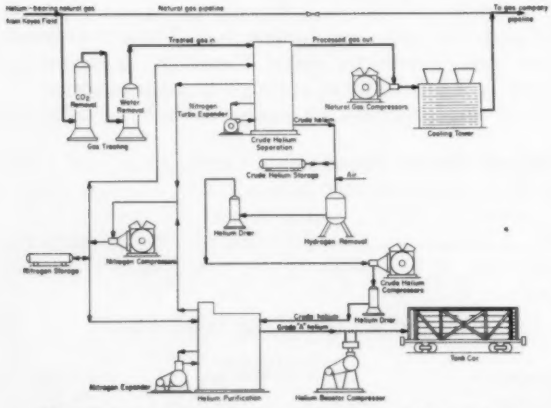

FIGURE 1—General schematic, Keyes helium plant.

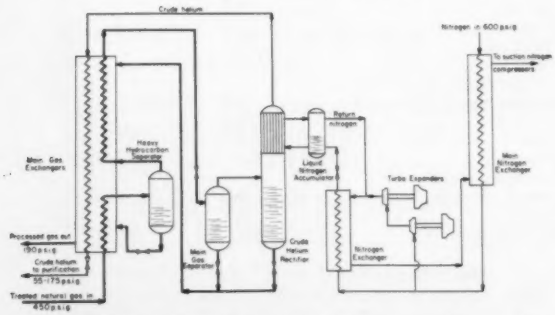

FIGURE 2—Schematic, crude helium separation cycle.

Gas Treating. Two gas-treating units processing 35 million cubic feet a day remove carbon dioxide and water from the inlet gas. Two units were provided to give flexibility of operation to accommodate seasonal fluctuation in gas supply and to permit the Bureau to meet a contractual commitment to process a fixed minimum quantity of gas without interruption from equipment being out of service.

The carbon dioxide removal plant processes natural gas with an inlet carbon dioxide content of 0.75 percent and uses a solution composed of 16 percent monoethanolamine, 72 percent diethylene glycol, and 12 percent water. Although the primary purpose of the amine-glycol solution is to remove carbon dioxide, the gas is also partially dehydrated because of the high glycol content of the solution.

Further dehydration takes place in a second contactor using an amine-glycol solution having a lower water content than the first. Solution for the second contactor is obtained by regenerating a side stream of the amine-glycol solution at a higher temperature to remove additional water. This second solution stream is about one-tenth the volume of the original and contains about 16 percent monoethanolamine, 79 percent diethylene glycol, and 5 percent water. The effluent gas stream from the second contactor contains about 0.005 percent (50 ppm) carbon dioxide and a water content of about 12 pounds per million cubic feet.

The gas then passes through an activated bauxite-filled dehydration tower, which contains a molecular sieve trimmer bed, where the water content is reduced to about 0.002 pounds per million cubic or corresponding to a dewpoint of about —100° F at 450 psig. The natural gas stream then is ready for low-temperature processing to separate the crude-helium product.

Crude-Helium Separation. The crude-helium separation process at the Keyes plant follows the basic process used at the other Bureau helium plants. Three identical, self-contained units, commonly called "cold boxes," are used to sep-

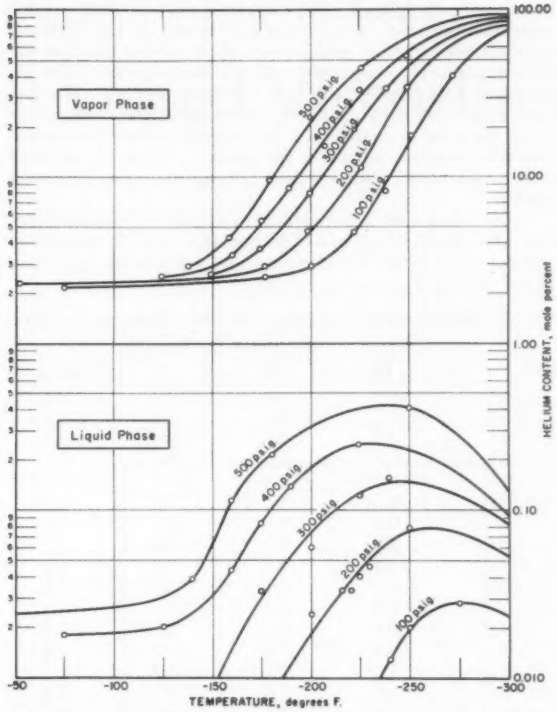

FIGURE 3—Equilibrium helium content of vapor and liquid phases of Keyes gas.

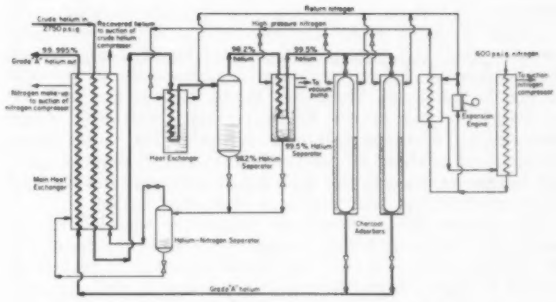

FIGURE 4—Schematic, helium purification cycle.

arate crude helium from the natural gas. Each has a design capacity of 23.3 million cubic feet of natural gas a day. Steps of the process are illustrated schematically in Figure 2.

Treated natural gas enters the main gas heat exchangers at 450 psig and is cooled to about —60° F. It then enters a heavy-hydrocarbon separator, where the condensed heavy hydrocarbons are separated and returned to the processed gas stream. Removal of the heavy hydrocarbons prevents formation of plugs in the coldest part of the process equipment.

Experience with a similar gas at the Amarillo plant had shown that certain heavy hydrocarbons could plug the low-temperature equipment if they were permitted to reach the coldest part of the equipment. Consequently, during design of the plant, laboratory tests were made with Keyes gas to determine temperature and pressure conditions of a heavy-hydrocarbon separator to yield a vapor phase that would not cause plugs when cooled to —250° F.

The combination of adequate gas treating and heavy-hydrocarbon separation has virtually eliminated the need for thawing the crude-helium units at the Keyes plant. Maximum time required between thawings has not been determined because other conditions have required taking units off stream before indication of need for thawing. Units have been on stream without shutdown for as long as 4 months.

After separation in the heavy-hydrocarbon separator, the vapor phase is returned to the main gas-heat exchangers and cooled further to —250° F by countercurrent heat exchange with the processed (outgoing stream) gas. At —250° F and 400 psig, about 94 percent of the gas is condensed.

The natural gas stream is then throttled into the main gas separator, which operates at —250° F and 225 psig. Experimental values obtained by the Helium Activity research laboratory for helium content of the vapor and liquid equilibrium phases at various pressures and temperatures are shown in Figure 3. Approximate composition of the vapor phase is 35 percent helium, 54 percent nitrogen, and 11 percent hydrocarbons, principally methane. Also present is about 0.1 percent hydrogen and a trace of neon.

This vapor stream is fed into the crude-helium rectifier, which is cooled with liquid nitrogen. The liquefied hydrocarbons are throttled to the return path of the main gas heat exchangers for countercurrent heat exchange with inlet gas.

Crude-helium from the crude-helium rectifier has a composition of about 79 percent helium, 20.8 percent nitrogen, 0.1 percent hydrogen, and less than 0.1 percent hydrocarbons. The crude-helium product, at about —300° F, is also returned to the main gas heat exchanger for countercurrent heat exchange with inlet gas.

Refrigeration for rectification of the crude helium is provided by a 600 psig, Claude-type, nitrogen liquefaction cycle. Dry nitrogen at 600 psig enters the main nitrogen heat exchanger, and is cooled to about —140° F where a portion passes through two stages of expansion in turbo expansion engines. The remaining fraction is cooled further in the nitrogen heat exchanger.

Liquid nitrogen is formed in an accumulator by throttling pre-cooled nitrogen at 600 psig down to about one atmosphere. Liquid nitrogen from the accumulator flows by gravity head into the condensing section of the rectifier. Cold nitrogen vapors from the rectifier and accumulator join the expansion engine exhaust and enter the return path of the nitrogen heat exchangers for counter-current heat exchange with inlet high-pressure nitrogen.

Helium Purification. Purification of the product from the crude-helium separation units is accomplished by three additional low-temperature processing steps. Prior to purification, the hydrogen content of the crude-helium stream is reduced from 0.1 to 0.01 percent by catalytic oxidation.

This step is accomplished at about 50 psig and ambient temperature by the addition of a small amount of air to the crude-helium stream just ahead of the hydrogen-removal equipment. Addition of air is controlled automatically to consume all oxygen and to leave a hydrogen content of about 0.01 percent. Every effort has been made to prevent oxygen getting past the catalyst bed because of the possibility of later concentration in the low-temperature system.

After the hydrogen content is reduced, the crude helium is dried with activated alumina and then compressed to 2,750 psig. Lubricating oil, introduced during compression, is removed in a charcoal filter and the stream is dried again.

Clean, dry high-pressure crude helium is then fed to the purification units.

Figure 4 shows the helium purification cycle schematically. Crude helium at 2,750 psig and ambient temperature enters the main heat exchanger and is cooled by countercurrent heat exchange with three effluent streams. Sources of these streams are described later. The inlet crude-helium stream is cooled and stabilized at —320° F in a heat exchanger by a liquid nitrogen bath. A separation is made in a gas-liquid separator.

The equilibrium vapor phase has a composition of 98.2 percent helium, 1.8 percent nitrogen, 0.01 percent hydrogen, and a trace of neon (6ppm). The 98.2-percent stream is cooled to about —340° F by a liquid nitrogen bath boiling at 3 psia. A second phase separation is made, and the vapor phase has a composition of 99.5 percent helium, 0.5 percent nitrogen, 0.01 percent hydrogen, and a trace of neon.

Liquid nitrogen from the 98.2-percent helium separator contains about 3.7 percent helium, and liquid nitrogen from the 99.5-percent helium separator contains a similar amount of dissolved helium. These two liquid streams are throttled to about 50 psig in the helium-nitrogen separator, where virtually all dissolved helium is released. The vapor phase is composed of about 37 percent helium and 63 percent nitrogen and is returned to the main heat exchanger, and warmed by countercurrent heat exchange with inlet crude.

The 37-percent crude-helium stream is recycled to the suction of the crude-helium compressors, and thus essentially all helium dissolved in the liquid nitrogen is recovered. Liquid nitrogen from the phase separator is also returned to the main heat exchanger and warmed to ambient temperature by heat exchange with the inlet high-pressure crude. This stream is about 99.9 percent nitrogen and 0.1 percent helium and is the source of make-up nitrogen for the nitrogen refrigeration system.

Final purification of the 99.5-percent helium stream is accomplished by adsorption of remaining impurities in one of two sets of charcoal adsorbers. These adsorbers are maintained in a bath of liquid nitrogen and produce helium of at least 99.995 percent purity, which is designated Grade-A helium.

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R. D. Haynes is chief of the Division of Engineering for the Bureau of Mines helium activity. After receiving his B.S. degree in chemistry from St. Mary's University of Texas, he joined the bureau in research and development work. In 1955 he was transferred to helium operations where he was responsible for technical operations of the four helium plants then in operation.

Haynes

Hydrogen remaining after the hydrogen removal step serves the purpose of signaling saturation of the charcoal adsorbers used in final purification. Hydrogen is the first significant impurity to appear in the effluent stream from the adsorbers. Detection of the first traces of hydrogen by sensitive analytical instruments in the parts-per-million range signals the need to switch to a regenerated charcoal adsorber. From the charcoal adsorber, the purified helium is returned to the main heat exchanger and is warmed to ambient temperature.

Table 4 shows trace impurities[2] in samples of helium taken from the purification units during the first 3 months of calendar year 1960. These results are considered typical of normal production.

TABLE 4—Impurities in Grade-A Helium Produced at Keyes

	Parts Per Million			
Date	H_2	Ne	N_2	Total ppm
1/11/60	0.5	5.5	2.3	8.3
1/13/60	0.7	4.9	0.8	6.4
1/16/60	1.2	4.9	0.0	6.1
1/19/60	0.5	5.5	2.0	8.0
1/22/60	0.8	5.4	0.5	6.7
1/26/60	0.6	4.6	0.4	5.6
1/27/60	0.4	5.3	0.0	5.7
1/31/60	2.3	5.7	1.5	9.5
2/9/60	0.4	5.6	3.9	9.9
2/11/60	0.9	5.8	1.0	7.7
2/15/60	0.4	5.7	2.2	8.3
2/25/60	0.8	6.1	1.7	8.6
2/25/60	0.4	5.6	0.2	6.2
2/25/60	1.1	5.6	0.9	7.6
3/12/60	1.0	5.9	2.7	9.6
3/21/60	0.6	4.1	5.2	9.9
3/24/60	0.5	5.2	2.5	8.2
3/28/60	0.6	5.5	0.2	6.3

Liquid nitrogen for purification units is also obtained from a Claude-type liquefaction cycle. Clean, dry nitrogen at 600 psig enters a nitrogen heat exchanger, and is cooled to about —166° F. About 80 percent of the stream is passed through a single-stage reciprocating expansion engine. The remaining 20 percent goes to another heat exchanger.

Liquid nitrogen is produced for the various processing steps by throttling high-pressure nitrogen from this heat exchanger. Flash vapors, combined with nitrogen vapors from other equipment using liquid nitrogen, join the expansion engine exhaust (—310° F), are returned through the two nitrogen heat exchangers and are warmed to ambient temperature by countercurrent heat exchange with the high-pressure inlet nitrogen.

Shipping Containers. Grade-A helium from purification units passes to the loading terminal and from there is charged into special helium tank cars. The tank cars are made up of 30 steel tubes, mounted in a framework. Each tube is 33 feet long, has an outside diameter of 18 inches, and has a wall thickness of 0.75 inch.

The tank cars are built under Interstate Commerce Commission Specifications 107A****. The tubes are made from steel having a tensile strength of approximately 105,000 psi. Each car has a specified filling pressure based on the minimum tensile properties of samples of steel taken from each tube when the cylinder is made. A car weighs about 235,000 pounds and costs approximately $110,000. The Bureau now has 157 helium tank cars in service. Filling pressures range between 2,100 and 3,675 psig with corresponding helium volumes ranging from 200,000 to 308,000 cubic feet measured at 14.7 psia and 70° F.

Tank cars having filling pressures below 2,750 psig are filled directly from the purification units. Cars having filling pressures above 2,750 psig are first filled to this pressure directly from the purification units and then are topped off by use of a diaphragm-type compressor.

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For petroleum fractions . . .

Liquid Viscosities at High Pressure

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A GRAPHICAL CORRELATION showing the effect of pressure on viscosity has been developed. The developed correlation is shown in Figure 1.

The ratio of viscosity at elevated pressure to the viscosity at one atmosphere is dependent upon pressure, the viscosity at one atmosphere, and the characterization factor, K_w, of the petroleum fraction. The characterization factor is defined as

$$K_w = \frac{\sqrt[3]{T_b}}{\rho_{60}} \qquad (1)$$

The characterization factor is usually conveniently ob-

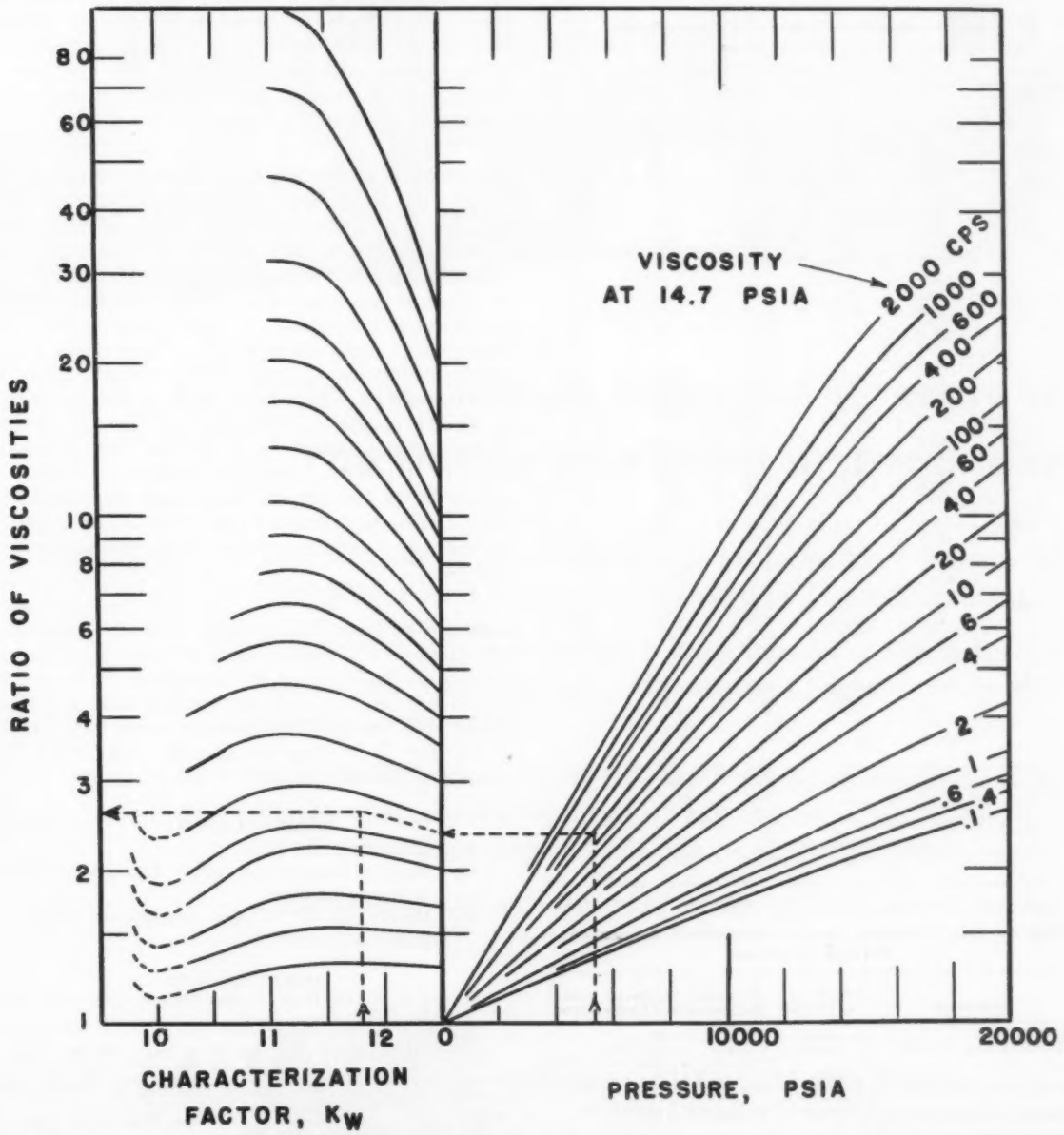

FIGURE 1—Isothermal effect of pressure on viscosities of liquid hydrocarbons at low reduced temperatures.

tained by relationships between commonly measured quantities as Saybolt viscosity, density, etc., as illustrated by a nomograph presented in PETROLEUM REFINER by Winn.[8] Table 1 shows numerical values of viscosity ratio dependent upon pressure and K_w suitable for drawing a graph identical to Figure 1.

Figure 1 is based primarily upon the measurements summarized by Hersey and Hopkins[4] that include pure hydrocarbons, lubricating oils, neutral oils, brightstocks, and distillates. Hartung[3] presented a summary article in this area. In addition, the more recent data of Griest[2] and Sternlicht[7] have been included. The data cover characterization factors from 10.9 to 12.5. For lower values of K_w the data of Bridgman[1] on pure hydrocarbons were used to extend the curves to a K_w of 9.8, but these are drawn as dashed curves to indicate uncertainty as to their application to low K_w petroleum fractions. The data were obtained between 32° F and 210° F, at relatively small reduced temperatures. The correlation is arbitrarily ended at 20,000 psia, although there is a diminishing amount of data extending to higher pressures. The accuracy of the correlation decreases as the pressure increases. At a pressure of 10,000 psia, and for viscosities less than 1,000 centipoises, Figure 1 predicts the viscosity ratio of petroleum fractions as reported with an arithmetical average deviation of 8.9 percent, with a plus trend of 1.9 percent.

TABLE 1—Numerical Values of Viscosity Ratios

Viscosity at 14.7 psia centipoise	Pressure psia	Values of Viscosity Ratio			
		Kw = 12.5	Kw = 12.0	Kw = 11.5	Kw = 11.0
0.1	4000	1.25	1.26	1.26	1.24
	8000	1.55	1.57	1.59	1.54
	12000	1.89	1.98	2.02	1.98
	16000	2.26	2.39	2.49	2.46
	20000	2.61	2.86	3.02	3.01
0.4	4000	1.28	1.29	1.29	1.27
	8000	1.61	1.66	1.68	1.63
	12000	2.00	2.11	2.20	2.15
	16000	2.42	2.67	2.83	2.82
	20000	2.88	3.14	3.39	3.41
1.0	4000	1.32	1.33	1.33	1.31
	8000	1.74	1.79	1.84	1.78
	12000	2.24	2.36	2.47	2.44
	16000	2.80	3.09	3.30	3.32
	20000	3.40	3.90	4.28	4.40
4	4000	1.47	1.49	1.51	1.46
	8000	2.16	2.28	2.40	2.36
	12000	3.10	3.42	3.70	3.80
	16000	4.32	5.23	6.03	6.08
	20000	5.81	7.85	9.60	10.1
10	4000	1.60	1.65	1.68	1.62
	8000	2.51	2.76	2.92	2.91
	12000	3.83	4.45	4.98	5.30
	16000	5.69	7.60	9.25	9.60
	20000	8.2	12.1	16.4	17.5
40	4000	1.78	1.88	1.92	1.87
	8000	3.10	3.43	3.75	3.81
	12000	5.23	6.60	7.85	8.1
	16000	8.5	12.8	17.2	18.3
	20000	12.9	22.5	33.0	36
100	4000	1.93	2.04	2.13	2.07
	8000	3.62	4.28	4.82	4.99
	12000	6.58	9.2	11.3	12.1
	16000	11.0	18.1	26	27.8
	20000	17	31.5	49	56
400	4000	2.11	2.22	2.32	2.30
	8000	4.49	5.55	6.41	6.63
	12000	9.0	13.9	19.1	20.1
	16000	16.4	30	47	52
	20000	25	53	87	100
1000	4000	2.31	2.52	2.68	2.65
	8000	5.25	6.8	8.25	8.55
	12000	11.3	18.7	27	28
	16000	21.7	42.5	68	76
2000	4000	2.47	2.71	2.88	2.87
	8000	5.90	8.0	9.8	10.5
	12000	13.4	23.2	35	38

TABLE 2—Fluid Properties Used in Generalized Correlation of Physical Operations

Operation	Number of Phases	Intensive Properties Used in Generalized Correlations
Fluid Flow	Single	Viscosity, Density
Convective Heat Transfer	Single	Viscosity, Density, Heat Capacity, Thermal Conductivity
Overall Tray Efficiency	Two	Viscosity, Relative Volatility
Capacity of Packed Columns	Two	Viscosity, Density
Molecular Diffusion	Single	Viscosity, Molal Volume

For viscosities exceeding 1,000 centipoises, hydrocarbon mixtures become non-Newtonian in behavior, with the apparent viscosity becoming less the greater the fluid motion. As an approximate rule of thumb, at the 2,000-centipoise level, a tenfold increase in velocity will result in a 20 percent decrease in apparent viscosity. The curves as drawn on Figure 1 represent the viscosity to be expected with moderate customarily used rates of flow, but the extra uncertainty of prediction in the high viscosity range should be recognized.

Significance of the Viscosity-Pressure Effect. Table 2 lists some of the physical operations where viscosity is used in generalized correlations as a pertinent variable. With gas absorbers operating above 2,000 psia, and hydraulic systems up to 6,000 psia, the estimation of the physical properties of liquids at such pressure levels is important. The viscosity is the physical property most drastically changed with pressure. For example, a light petroleum fraction at room temperature and 6,000 psia as compared to atmospheric pressure has an increase in density of about 2 percent,[6] an increase in heat capacity of 2 percent,[6] an increase in thermal conductivity of 8 percent,[5] and an increase in viscosity of around 50 to 100 percent. Such large increases in viscosity cannot be ignored. Figure 1 should be helpful in conveniently computing these large viscosity-pressure relations.

Example of Use. The viscosity of an oil is desired at 5,400 psia with a characterization factor of 11.8 and a viscosity at 14.7 psia of 90 centipoises. Following the dashed lines on Figure 1, the viscosity ratio is 2.37 for $K_w = 12.5$. Interpolating between curves as a function of K_w, for $K_w = 11.8$, the viscosity ratio is 2.6. The viscosity of the oil is $2.6(90) = 234$ centipoises.

NOMENCLATURE

- K_w Characterization factor
- T_b Mean average boiling point of petroleum fraction in degrees Rankine
- ρ_{60} Density at 60° F and atmospheric pressure in grams/cm³.

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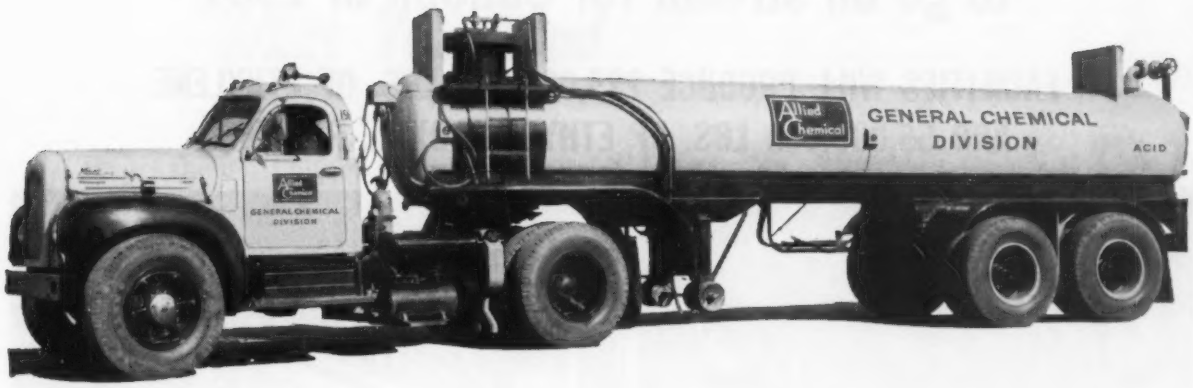
Now... HF by Tank-Transport Delivery



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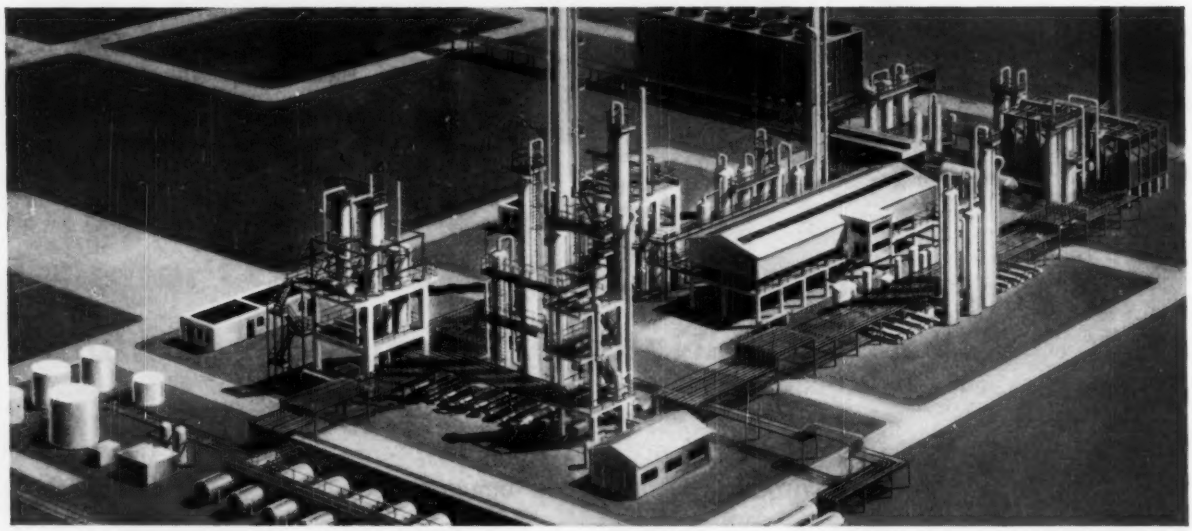
New $20 million Ethylene and Ethylene Oxide plant to go on stream for SunOlin in 1961

FACILITIES WILL PRODUCE 225,000,000 LBS. OF ETHYLENE AND 55,000,000 LBS. OF ETHYLENE OXIDE PER YEAR



The Lummus Company has been awarded the contract to design, engineer and construct a $20 million ethylene and ethylene oxide plant for SunOlin Chemical Company at Claymont, Delaware.

The plant is scheduled to go on stream late in 1961, and will have a design capacity of 225,000,000 lbs. of ethylene and 55,000,000 lbs. of ethylene oxide per year. Existing facilities will be modified to permit production of 12,000,000 cubic feet of high-purity hydrogen and up to 1,000,000 cubic feet of carbon monoxide per day.

The new units will be located at Claymont, Delaware, adjacent to the Sun Oil Company's Marcus Hook Refinery which will supply the raw material for the plant.

A substantial portion of the products produced will be used to supply the requirements of major chemical companies in the area. To permit efficient delivery of ethylene and other petrochemicals, a multiple pipe line crossing will be laid under the Delaware River from the site to serve customers in the expanding Southern New Jersey industrial area.

The remainder of the production will be used in the manufacture of products marketed through existing sales outlets of Sun Oil Company and Olin Mathieson Chemical Corporation, the joint owners of SunOlin.

The plant will employ Lummus' low-temperature ethylene separation process, which provides high separation efficiencies and unusual flexibility and reliability; and Shell Development Company's ethylene oxide process, which offers the advantages of unusually high yields and virtual elimination of waste disposal problems encountered in the classic Chlorohydrin Process.

SunOlin is the fourteenth ethylene, and the fifth Shell Process ethylene oxide plant to be designed, engineered, and constructed throughout the world by Lummus.

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RAPID READING 2

Grasp and Remember What You Read

To get the most out of your reading, you'll have to absorb details and recall them later. Techniques given in this interesting article will tell you how

Nila B. Smith, The Reading Institute
New York University

IN THE FIRST PART of this series last month, you learned about the techniques to use in reading fast, in previewing and in finding the main idea. I hope you have been practicing these techniques during the past month and have noted improvement. If so, you are now ready for the additional procedures which will be discussed in this article.

GRASPING DETAILS

Today, men in the oil industry and science have to read much technical material—in fact, the content of the bulk of their reading is packed with detailed facts and explanations. While it isn't possible to read such material with the same speed that one reads a light story, it is possible with training to learn to read it much more rapidly, than most people do. New techniques also enable you to grasp details with better understanding and less arduous effort and confusion.

If anyone needs help in reading detailed information more efficiently, certainly those whose interests lie within the realm of subjects treated in PETROLEUM REFINER need such help. Therefore, the first topic to be treated in this installment deals with how to read details.

Using Old Skills. The ability to do detailed reading rapidly and well is a complex process requiring the combination and application of many different reading skills. That is why instruction in and practice on this type of reading was delayed in this article until you mastered the elementary skills presented last month.

In reading for details you need to know how to preview so you can decide whether the material is of sufficient interest to be read for details. And, of course, you need the skill which you have been acquiring in learning to read fast, in order to increase your tempo in reading for details. Most of all you will need the skill of locating quickly and surely the main idea in a paragraph. All of these skills were discussed in the first installment of this article.

Learning New Skills. You also need to learn two very important new skills: First, learning to discriminate between main ideas and details; second, learning to organize details around the main ideas. After considerable practice in analyzing paragraphs and organizing details, you will reach a point where you will read factual material in groups of meanings rather than in isolated scraps.

Making use of the pattern of a paragraph's organization is the first essential in learning to grasp details readily and easily. A well-organized paragraph may be compared to a river system. Think of the large river, itself, as the main idea, larger branches running into the river as major details, and the smaller brooklets running into the branches as *minor details*. When you can visualize the pattern of a paragraph as clearly as you can see the pattern of a river system on a map, then you are well on your way to becoming an expert in reading details.

Picturing the Paragraph. You should be able to find main ideas, even in difficult material quickly and accurately at this point if you have practiced doing this since the last article appeared. The use of this skill is your starting point in grasping details. Find the main idea first of all. Then find the larger more important things that are said about the main idea. Then, of course, if you are reading to master all of the small facts, you will need to find out additional information given about the major details, or the minor details.

You can't make much improvement in your ability to read difficult factual material until you can quickly tell the difference between major and minor details. The first step is to develop the ability to "spot" major details as, it is hoped, you have already become skillful in "spotting" main ideas. Let's analyze a paragraph for the main idea and major details.

The following paragraph was taken

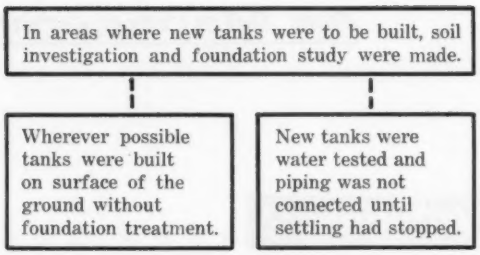
In areas where new tanks were to be built, soil investigation and foundation study were made.
Wherever possible tanks were built on surface of the ground without foundation treatment.
New tanks were water tested and piping was not connected until settling had stopped.

FIGURE 1—Here's a diagrammed paragraph the way you would see it using the "picture paragraph" technique (see full paragraph in upper left-hand corner of this page).

from an article describing what was done to meet the problem of the Esso Standard's Bayonne refinery where the soil was not firm enough to support the weight of a tank.

"In all areas where new tanks were to be built, an intensive soil investigation and foundation study were made to accurately evaluate the strength of the natural soils. Wherever possible, tanks were built directly on the surface of the ground without any special foundation treatment. Newly completed tanks were carefully water tested and the piping was not connected until all settling under the water load had stopped."[4]

In reading this paragraph, you no doubt would immediately decide that the main idea was: "In areas where new tanks were to be built, soil investigation and foundation study were made." Perhaps this is all you would want to know. If, however, you decided that you would like more information about the soil investigation and the foundation study, you would read the two additional and equally important statements, one about the foundation and one about soil testing. These are the major details budding out of the main idea.

Diagrammatically, the structure of this paragraph looks like Figure 1.

Major Details. There are many paragraphs whose main idea is accompanied only by major details, that is, the statements that expand upon the main idea are all of about equal importance. To do a good job of reading such paragraphs you need to recognize these major details as being comparable in significance, and grasp them as a cluster related to and telling more about the main idea.

The more difficult paragraphs are those which are made up of a main idea with major details sprouting out of this one big important idea, and then with minor details in turn sprouting out of the major details. It is in this kind of reading that many readers get lost. They do not sense the interrelationship of the details, attribute equal importance to all of them, and often try to understand and remember each detail in isolation and unrelated to the whole.

Take the paragraph below, for example. See if you can quickly locate the main idea, "spot" the major details, then envision minor details growing out of the major details.

"Unfortunately, when a thrust failure occurs, the bearing itself is usually totally wrecked. This makes it practically impossible to check and compare clearances or dimensional checks to original drawings and recommendations. But there are other possibilities that can be found. Look for small parts, retaining or locating members and leveling assemblies that have worked loose or have been improperly installed. On tilting shoe bearings, fretting under load carrying buttons is an indication of a misaligned thrust collar. Axial alignment of the thrust collar can be checked on the undamaged side using indicators." [5]

If you clearly delineated the main idea, major details and minor details, you visualized the structure of the paragraph in some such way as in Figure 2.

In this case there are two major details growing out of the main idea, and three minor details budding out of one of the major details. In long, complicated paragraphs there are sometimes three or four major details, each of which carries several minor details. Your technique for unraveling such a paragraph will be unfailing, however, if you first "spot" the heart (main idea) of the paragraph, then grasp clusters of details as they are related to the main idea, and to each other.

Practice and Application. Now you know an effective procedure to use in reading detailed factual or technical material. But simply having the "know-how" isn't enough. As is the case with the other reading skills, you must practice to become expert. Put into effect the technique of picking out and visualizing the relationships of the parts of a detailed paragraph when you are reading in your trade or professional magazines or books. Diagram or outline some paragraphs on a separate piece of paper, or within the paragraph itself; or make notes on the margin of the page; or underline main ideas and major and minor details with one, two, and three lines, respectively. Continue to use these helps as long as necessary. As soon as you can, however, try to get away from the use of such "crutches," for they slow up speed. With practice, you will reach the point eventually where you will automatically grasp the structure of a paragraph at a glance.

When you have achieved a high degree of skill in working with separate paragraphs, proceed to carry out the following suggestions.

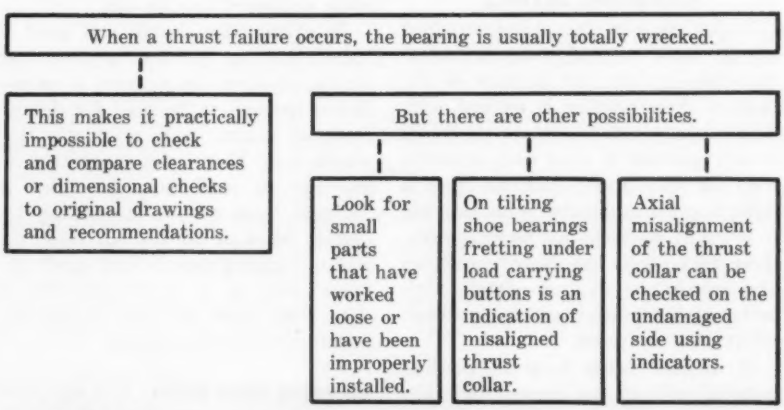
When a thrust failure occurs, the bearing is usually totally wrecked.
This makes it practically impossible to check and compare clearances or dimensional checks to original drawings and recommendations.
But there are other possibilities.
Look for small parts that have worked loose or have been improperly installed.
On tilting shoe bearings fretting under load carrying buttons is an indication of misaligned thrust collar.
Axial misalignment of the thrust collar can be checked on the undamaged side using indicators.

FIGURE 2—Do you grasp major details of your reading quickly? Here's how you would visualize major and minor details of the fourth paragraph under subheading "Major Details" on this page.

"A common complaint of adult readers is that they can't remember what they read. If this description fits you, don't blame your memory—blame your habits. Then read this article and get on the road to rapid reading"

Set aside at least one 15-minute period each evening for practice on reading detailed, factual articles. In each of your practice periods, select an article of this type and apply the techniques which you have learned. Work with one paragraph and try to envision that as a whole. Then go on to the next paragraph and proceed as if it were a new unit. Stop frequently to sum up what you've gotten out of two or three paragraphs. You will soon be able to make an easy transition from one paragraph to another and to grasp details in increasing numbers of paragraphs.

As soon as you can read two or three paragraphs without stopping, make an entry in your notebook: "Speed Record—Detailed Reading." Enter the date and the number of words per minute which you were able to cover in reading material packed with facts. Continue to keep this record each night until you read detailed material as fast as you want to. You should make regular rate increases in this kind of reading—but remember this rate will never be so high as your speed in reading easy, narrative material.

REMEMBERING WHAT YOU READ

A common complaint of adult readers is that they cannot recall what they read. They frequently phrase it: "I seem to understand what I read when I'm reading, but later when I try to tell someone about it, or to put it into use in my work, it's gone. I can't think of it! I must have a poor memory."

Don't blame your memory. If you are healthy and have average intelligence you have as good a memory as anyone else. Memory is not an organ that is weak or strong. It is a function. Make use of it or let it lie dormant, as you prefer. But if you do the latter, don't blame your memory. Blame yourself for not using it properly.

The person who complains that he has a poor memory is the one who has not directed his attention strongly toward any particular items in the article or whatever he is reading. No doubt he has passed over the lines of print in an effortless manner, recognizing masses of words and myriads of meanings indiscriminately, conveying only weak and feeble impressions to his brain. Such impressions are not stamped into the "storage grooves" with sufficient impact to permit ready recall, at a later time.

Knowing, then, that you are as capable as anyone else of recalling what you read, trust your memory. Don't condone it or view it with suspicion. Make such use of it that you won't have to excuse its failures.

Of course, not all of the material that you read is worthy of the effort of trying to remember it. However, when you read something that you actually *want* to recall, follow these suggestions.

1. Set a Purpose. No doubt you will have some reason for wanting to remember the content of certain reading material. Stating your recall purpose to yourself is your first step. If you have a definite purpose clearly in mind for recalling certain facts, you are more apt to focus strong attention upon these facts, and this is important.

Purpose is something which has been emphasized from the beginning of these two articles. You have been urged always to set a purpose for yourself before reading. You have been told that having a definite purpose for reading a selection contributes both to your speed and comprehension. Now we tell you that whatever fills your purpose will probably be that which you will want to remember.

2. Be Selective. Select what you want to remember. Don't try to remember everything on the page. Select the main ideas, or the clusters of details, or the numbers, or the particular things you wish to remember. Think as you read and select carefully those things you wish to have remain in your mental storehouse.

3. Develop Strong First Impressions. When you begin to read, try to keep your first impressions strong and clear. If you mull over an article or a chapter the first time you read it, you are off to a bad start in remembering the information it contains. Think clearly as you read a page the first time and make sure that you understand what it says. Strong first impressions are very important in recalling what you read later.

4. Concentrate. One often hears adult readers say, "I can't concentrate on what I'm reading." These individuals usually are able to direct their initial attention to some reading matter which they desire to retain, but they have difficulty in holding it to the task at hand.

The power of concentrating attention on what you read breaks down into two components: Exclusion and "staying on the track." Exclusion means the ability to shut out all sights, sounds, and thoughts except the one on which you wish to concentrate, thus giving 100 percent of your attention to the reading content. Divided attention won't yield a vivid impression. If, when focusing your attention on a text that you wish to remember, you can become absolutely oblivious to everything else in the world, then you will get the strongest possible impression. As you have learned previously, strength of impression is in proportion to strength of attention.

If you haven't been in the habit of concentrating 100 percent on what you read, you will find that it will take will power and effort to form the new habit. But with practice you will eventually be able to concentrate your attention on those items you wish to remember almost automatically and with very little expenditure of effort. Be patient, for improvement in concentration is gradual; but once you have established a new mental pathway leading straight ahead without branching off at distractions, your mind will travel over this pathway without special effort. Clear away the brush and build a well-established mental road; then your mind will not explore the many bypaths into the forest of forgetfulness.

Have you noticed that you now are concentrating better than before you began to work with the techniques in these articles? The answer should be in the affirmative because

every technique learned so far has made its own contribution.

Take reading under time pressure, for instance. If you are forcing your speed to see how many words you can read and understand within a given time, you are apt to stick pretty closely to the job. You won't have time to let your mind run off on side excursions. Striving to see if you can beat your own record in reading more words per minute is one of the best antidotes for an itinerant mind.

The skills that you have learned to use in tackling different types of reading materials for different purposes have also contributed to concentration of attention. People who are not equipped with specific reading skills often laboriously "plow through" everything in one manner. The application of just one general-reading procedure to all reading situations is in itself conducive to wandering attention. Knowing just how to undertake the job of reading a specific selection for a specific purpose, and how to use a certain combination of skills which best serve that purpose, enables you to get at the heart of things without lost time and effort. You already save time that you might otherwise spend in dispersing your attention here and there.

So, even though concentration has not been mentioned in preceding headings, you have ever since the first page of these articles, been developing skills which contribute to concentration, and concentration is a *must* in remembering what you read.

Other Aids. Here are some other aids which will sharpen your ability to recall.

1. Take Time to Think. Reading to recall what you read should not be just a routine matter of memorizing bare facts. To be successful in recalling you need to take time while you are reading to think, reflect, synthesize related parts, and get the entire "picture," with details marching along where they belong in the total formation. This cannot be done hurriedly. Speed reading techniques usually have little or no function when a person is reading for the express purpose of recalling detailed facts.

2. Repeat the Information to Yourself. After you have tired to fix an idea or a group of ideas in mind, then raise your eyes from the page and repeat the information to yourself one or two or more times. Each time you are ready to repeat a new idea or group of ideas, go back and repeat all of the others that you have repeated to yourself previously. Recalling the whole chain of facts or ideas as one leads into another is a procedure which is much superior to that of trying to remember and recall separate facts or ideas by themselves.

3. Pencil Work Helps. If you want to remember facts gleaned from reading for the purpose of giving a speech, conveying information to an employe, taking an examination (it is assumed that many people in the industry continue to take courses after college days are over), then you will find it helpful to use as many different avenues of impression as possible, that is let the facts come to you through several different senses. When you read the facts you see them; when you repeat the facts to yourself you say them and hear them. Now use another avenue for receiving impressions — use your pencil and get the feel of working with them.

Some people find it helpful to write an outline of an article or chapter, then memorize the outline as a "skeleton" to use in recalling details. Still others prefer to write a summary, usually of one paragraph for each topic. Then they use this summary as a basis for recalling facts. Others find it helpful to underline key words or parts of key sentences directly in the text. Then they refer to these underlined parts as a help in remembering facts.

4. Review for Permanency. If you wish to make use of the information immediately probably you will be ready to do this after putting into effect these suggestions. If, however, you wish to lay away the information, permanently, go back to it and review it at spaced intervals until you are sure that you have made it your own.

5. Practice. As an initial trial, find an article in this issue of the REFINER which contains information that you would like to remember. Apply the points given above in reading to fix this information for recall.

If you wish to develop yourself to a high level of efficiency in reading to recall, go on practicing these procedures whenever you read an article or chapter that you wish to remember. Make the best possible use of the techniques of setting a concise purpose, establishing strong impressions, concentrating intensively, repeating to yourself, reviewing. These are the essentials in reading to remember, so work on them continuously until they become automatic.

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[5] Noack, M. R. "Why Compressor Thrust Bearings Fail," PETROLEUM REFINER, Vol. 39, No. 2, (February 1960), p. 159.

NEXT MONTH . . . Part 3—"Skim Reading—Blessing to the Busy." The busy executive and engineer must digest vast amounts of literature. And, speed in doing this is of the utmost importance. Whether you're in the "busy man" category or just want to improve your reading skill for improvement's sake, be sure to read this stimulating final part to the "Rapid Reading" series. Look for it in your April PETROLEUM REFINER.

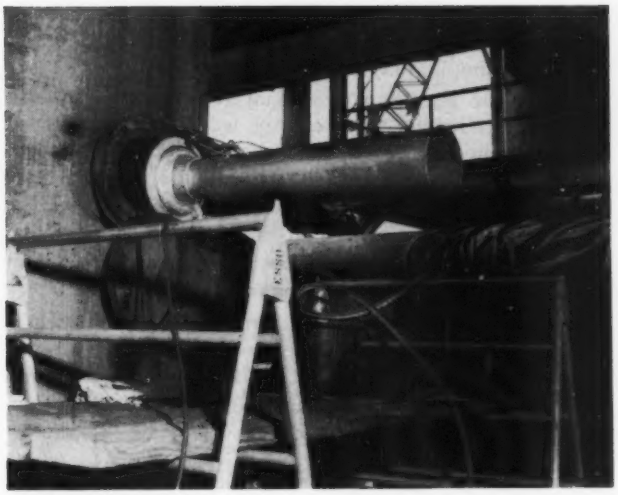

FIGURE 1—Exhausters installed without sealing handle more outside air than work-space air.

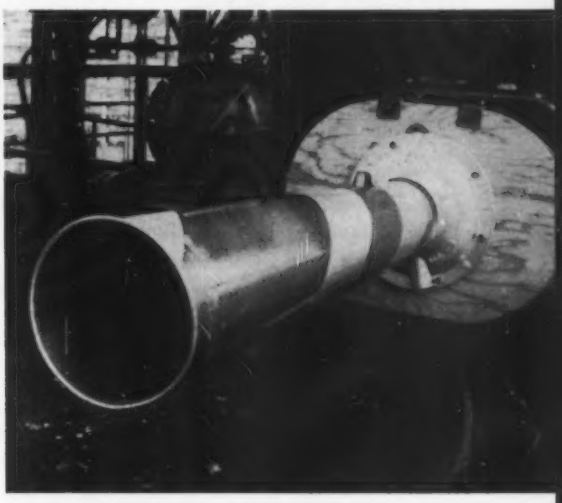

FIGURE 2—An adapter plate offers this simple solution to air "short-circuiting."

TIPS FOR TURNAROUND VENTILATION

Ventilation can't turn a turnaround into a hard-hat haven. But it can relieve some of the headaches which refiners and their men face when process equipment needs "hot work" inside

L. W. Raymond and F. W. Church
Esso Research & Engineering Co.
F. S. Venable and J. D. Yoder
Esso Standard Oil Co.

WORK DONE INSIDE process equipment often causes serious health problems through the presence of toxic or irritating materials. This is especially true when welding, torch cutting and related jobs are done in these confined work spaces. Through careful study, Esso Research & Engineering Co. has come up with the following 11 tips for turnaround ventilation. Does your plant employ them?

1. Encourage field supervisors, foremen and crews to take the time to ventilate enclosed work spaces.

2. Use exhaust air-flow techniques when possible.

3. Seal exhausters to avoid "short-circuiting" by mounting them on plywood blanks shaped to fit manhole.

4. Whenever possible, avoid placing ventilators on openings needed for access or materials-handling.

5. Downflow air patterns are usually better for torch cutting and downhand welding. For overhead welding, upflow systems get the nod.

6. When nozzle welding, try to hold off flanging up the line until continuous welding of nozzle is complete.

7. Air-driven ventilators of the ejector type are effective as exhaust devices, and should have periodic maintenance and flow-rate checks.

8. Tandem work (in which several welding jobs are going on at once, at different levels of a tower) makes fume control more difficult.

9. If heat load is severe, it is sometimes helpful to use cooled air as supply of "push-pull" ventilation set-up.

10. Include ventilation in pre-turnaround planning-session topics.

11. Designers and detailers—keep ventilation and materials-handling in mind if possible, when laying out vessel openings and side streams.

For some time before coming up with these recommendations, Esso Research & Engineering Co. had been concerned with the efficiency of ventilation for fume control in confined spaces. To study control effectiveness, an industrial-hygiene research program was outlined with field measurements of fume reduction as its method of attack. Esso refiners cooperated so that research could be done under realistic turnaround conditions, and thus lead to practical conclusions.

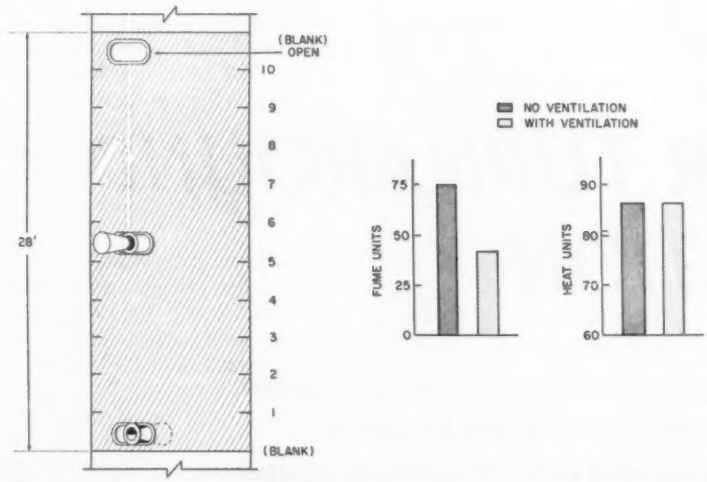

FIGURE 3—This ventilation scheme helped a little, but was judged not effective enough. Method consisted of removing support rings from 10-foot diameter tower in alkylation plant; one burner, torch cutting on rings 3 and 4. Ventilation by push-pull upflow scheme—exhauster in middle manway (1,035 cubic feet per minute) and blower in bottom (680 cfm).

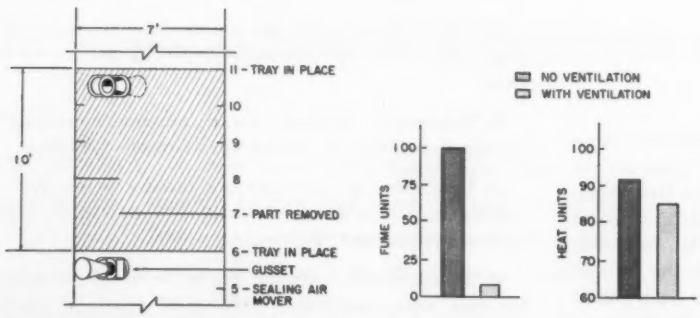

FIGURE 4—Downflow scheme and a well-installed exhauster are credited with this good showing. This is a seven-foot-diameter tower, alkylation plant; one burner, torch cutting on tray 7. Ventilation by push-pull downflow: Exhauster, 1,480 cfm; blower, 1,870 cfm.

Simple Approach. Initial field studies employed a simple approach. Matched measurements of fumes and heat—taken first with ventilation and then without—were compared to judge how effective a ventilation job the company was doing in more than 20 specific cases. Some examples may be helpful to illustrate.

In Case A, the experimental ventilation set-up was somewhat helpful as a control technique, but not effective enough. As Figure 3 shows, the "push-pull upflow" ventilation reduced the breathing-zone fume level by 45 percent. Heat load was unchanged, however. The performance picture seen in this case is typical of that shown by ventilating schemes in a number of other instances—helpful, but inadequate.

Case B involved a job similar to Case A, done in a smaller tower. A different ventilator arrangement was used, as shown in Figure 4. Much better fume and heat reduction resulted. The following three factors account for the improved showing.

- The exhaust ventilator was fitted with an adapter flange, shaped to the manhole opening (see Figures 1 and 2). This simple change prevents "short-circuiting" of air handled by exhausters.

- In both cases, the point of fume emission (the cutting flame) was below the burner's *breathing* zone. Working downhand, the burner would naturally stand a better chance of breathing clean air with downflow (Case B) ventilation in use.

- Case B involved a higher *rate* of ventilation: more air was being handled, and the tower diameter was smaller. Based on exhaust flow figures, nominal velocities (cfm per unit area of tower cross section) can be calculated as shown in Table 1.

It is important to recognize that the presence of high flow rates does not necessarily insure good fume control, unless the ventilators are thoughtfully applied to the work situation. When high nominal velocities are accompanied by unfavorable distribution, poor control results. Occasionally this was observed in field studies, from which two examples are offered in Table 2. The effect of ventilation rate was studied further in ensuing work, described later.

Intensive Study. Preliminary studies justified a more intensive examination of the problem. With many independent variables active in the relationship of heat and fume to work-space conditions, it became dif-

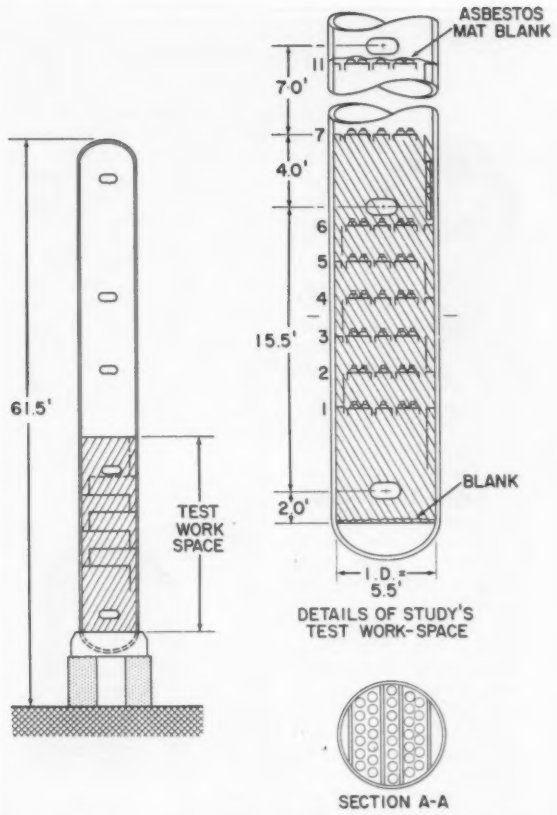

FIGURE 5—This distillation tower, taken off stand-by status, provided a test work space for ventilation tests. Notes: (1) Tray spacing 2 feet C-C, (2) typical downcomer underflow slot, 3 feet long 1 inch wide.

ficult to get truly matched measurements upon which to base conclusions about *ventilation* performance. In some instances, field conditions changed so much between runs that "with ventilation" levels of fume and heat exceeded "no ventilation" ones.

To eliminate the uncertain and complicating effects of variable field conditions, the second stage of the research program was carried out in a single location. By using a single work-space and by controlling other important factors, it was possible to focus sharply upon the fume-reducing effects of the ventilation.

When the Baton Rouge refinery of Humble's Esso Standard Division made available a stand-by gas absorption tower (see Figure 5), the study of ventilation techniques under controlled conditions came out of the planning stage.

Five ventilating set-ups were tested at several different flow rates. To keep the tests realistic, it was decided to control the conditions for a number of typical combinations:

(1) Work—welding and torch cutting (downhand position).

(2) Tray level between adjacent manways—upper, intermediate and lower.

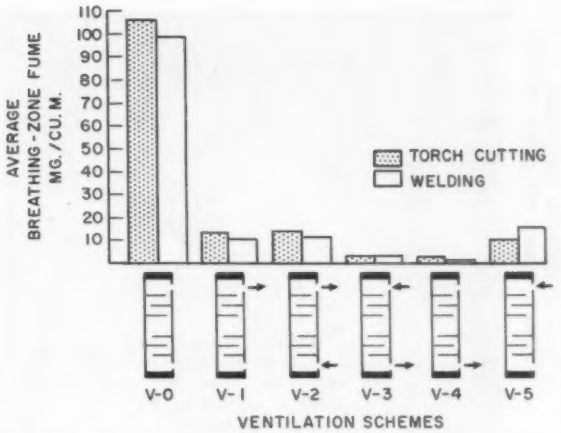

FIGURE 6—Performance of five ventilation schemes for torch cutting and welding, tested at the same flow.

TABLE 1—Calculation of Nominal Velocities

	Diameter Feet	Area Sq. Ft.	Exhaust Flow cfm	Nominal Velocity lfm
Case A	10.0	78.5	1,035	13.2
Case B	7.0	38.5	1,870	48.6

TABLE 2—Unfavorable Distribution = Poor Control

	Diameter Feet	Area Sq. Ft.	Flow cfm	Nominal Velocity lfm	Fume Units
Case C	10.0	78.5	1,870	23.8	105
Case D	10.0	78.5	4,700	60.0	47.5

TABLE 3—Flow-rate Descriptive—Term Numbers

DESCRIPTION	Air Flow Cu. Ft. Per Min.
High	2,500
Moderate	1,600
Low	1,000

(3) Location of work-point on tray—center, far edge, near edge (with reference to manway).

The average performance of each of the test ventilation techniques is shown in Figure 6. The very high levels found under "no ventilation" conditions offer a basis for comparison. In looking at this plot, it is well to note several other facts:

(a.) Performance of each set-up is shown here for *moderate* flow. When the study's high-flow rate was used, average performance was about eight percent better. The average showing of low-flow runs was poorer by a like amount.

(b.) In specific cases, reversals of the *over-all* picture were seen. For instance, when welding was done on the

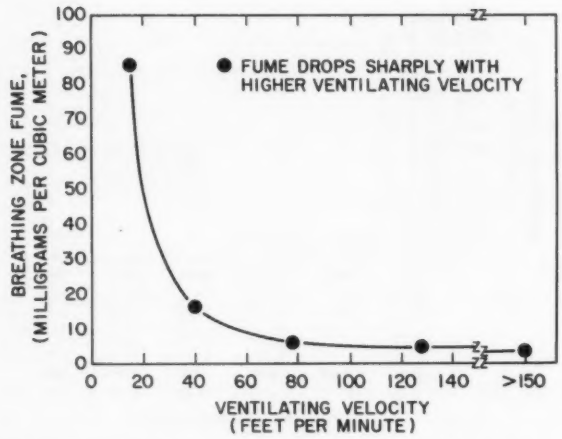

FIGURE 7—This graph illustrates how sharply the fume rate drops with higher ventilating velocity.

"manhole edge" of the test vessel's middle tray, the low-flow performance of set-up V-3 was poor, because of a back-water air pattern.

(c.) Heat data are not shown, but they follow the general trend of fume findings.

(d.) Throughout this stage of the study, exhaust ventilators were fitted with adapting flanges to avoid "short-circuiting."

Approximate numbers which apply to the descriptive terms used above for flow rate are shown in Table 3. These rates were used for two reasons. From initial studies, they seemed suitable for realistic testing of the five set-ups used to ventilate a tower with a circular cross section of 23.8 square feet (tower diameter, 5.5 feet). At the same time, there was a limit to the maximum flow which could be conveniently obtained with commercially available ventilators.

Ventilating Velocity. Other field measurements were taken in addition to heat and fume levels. Among them is one which seems to tie in closely with fume level. (See Figure 7.) Called "Ventilating Velocity (VV)," it is simply the velocity of air passing through the breathing zone of the welder or burner. The directional aspect of VV offers a good explanation for its close tie-in with fume control. It is measured in the direction of the air-handling opening which is closest to the mechanic. In this way, VV tries to express:

- How fast *clean* air is coming to the breathing zone of a welder who is near a *supply* opening, or

- For a man working closer to an air-*exhausting* opening, how fast *contaminated* air is being removed.

Though Figure 7 is based on data from a single study, it indicates something that probably applies to many confined-space jobs. Even a small amount of air motion can help out a lot *if it is directional,* and if *it reaches the breathing zone.* # #

About the Authors

Raymond

Lawrence W. Raymond is an industrial hygiene engineer for Esso Research & Engineering Co., Linden, N. J., where he conducts basic industrial-hygiene field studies among Standard Oil Co. (New Jersey) affiliates. Holder of a B.S. degree in civil engineering from Manhattan College and S.M. degree in engineering from Harvard University, he has also studied science courses at Rutgers University. Mr. Raymond has been with Esso Research & Engineering in industrial hygiene work since 1957.

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Church

Venable

Fred S. Venable is an industrial hygienist for Esso Standard Oil Co., Baton Rouge, La., where he works in the prevention of occupational disease through environmental control. Holder of a B.S. degree in chemical engineering from The University of Texas (1947) and M.S. degree in industrial hygiene from Harvard University (1949), Mr. Venable has been with Esso at Baton Rouge since 1951. From 1947-51 he worked for the Bureau of Sanitary Engineering, Texas State Department of Health.

John D. Yoder is an industrial hygienist for Esso Standard Oil Co., New York, where he specializes in the study and control of work-environment health aspects. Holder of a B.S. degree in sanitary engineering from Pennsylvania State University and a M.S. degree in hygiene from Harvard University, he has done additional graduate work in radiological physics and industrial hygiene at the University of Rochester. Previously with Esso Research & Engineering Co. since 1955, he joined Esso Standard this year.

Yoder

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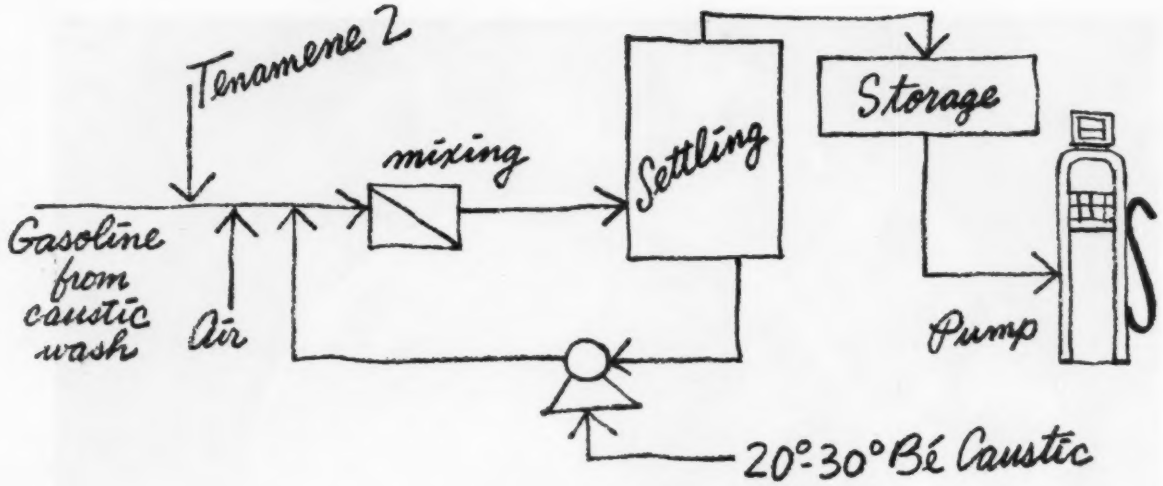

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Tenamene 2 inhibitor sweetening is primarily of interest to processors of catalytically-cracked gasoline. The response of such gasolines to the inhibitor sweetening method can be quickly determined by the following test:

1. Using sour gasoline from the primary caustic scrubber or mercaptan removal unit, put 700 ml. into each of several one-quart bottles.
2. To one group of samples, add Tenamene 2 at a rate of 5 pounds/1,000 bbls. (14.25 mg./liter). To another, add 10 pounds/1,000 bbls. (28.52 mg./liter).
3. Add 10 vol. % of 15° Baumé caustic to each sample.
4. Stopper the bottles, shake thoroughly. Replace stoppers with notched corks and store samples in a dark place at room temperature.
5. Examine at 3-hour intervals and determine the time required for sweetening.

If the results of this test indicate Tenamene 2 inhibitor sweetening to be effective in treating your sour gasoline, we will be glad to aid you in making a detailed study of your sweetening and stabilization requirements. In this study we will help you determine the optimum processing values for your particular operation, including inhibitor concentration, caustic strength and proportion, acid oil content, process temperature and reaction time. For an evaluation sample of Tenamene 2 and more information on the Tenamene 2 inhibitor sweetening method, write or call your Eastman representative, or write to Eastman Chemical Products, Inc., subsidiary of Eastman Kodak Company, Kingsport, Tennessee.

Basic Procedure for Tenamene 2 Inhibitor Sweetening
(see sketch)

The sour gasoline is washed with 10-15° Baumé caustic. Between 5 and 15 pounds of Tenamene 2 is added per 1000 barrels of hydrocarbon. A small quantity of air is injected into the stream and the gasoline contacted with 20°-30° Baumé caustic. The gasoline is allowed to settle, then pumped to storage. If not already sweet when it goes to storage, the gasoline should sweeten within a few hours after storage.

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Test Yourself on Labor Relations

No. 1. Refusal to Work Overtime

Business had been good, so the company offered Joe Hernandez and other employes about six hours overtime a week. But when business slackened, Joe went on a regular 40-hour stint. To make up his "lost income," he got a second job. As a result, his work suffered. He began to leave five or ten minutes early and often came in late. His supervisor talked to him, and his habits improved.

Then business took a big upturn. The company put all production employes on a 48-hour week—giving each man eight hours overtime. Joe said he couldn't accept overtime because it would interfere with his second job. He was told he would have to work 48 hours, or be dismissed—so the company could replace him with somebody who could work overtime. When Joe still refused to work overtime, he was fired. At arbitration he argued:

1. The regular workweek is 40 hours. Extra hours should be voluntary.
2. I have a big family and I must supplement my income.
3. I'll give up my second job if I'm guaranteed 48 hours a week.
4. The company has no right to interfere with my outside activities. I do a good job and have nothing against my record.

The company said:

1. We have a right to ask workers to put in reasonable overtime. Otherwise we couldn't meet our schedules.
2. We can't offer a guarantee of a 48-hour week to anyone. Business is not that certain.
3. A man's first loyalty is to his regular job, not his second.

Test Yourself:

Was the company: Right ☐ Wrong ☐

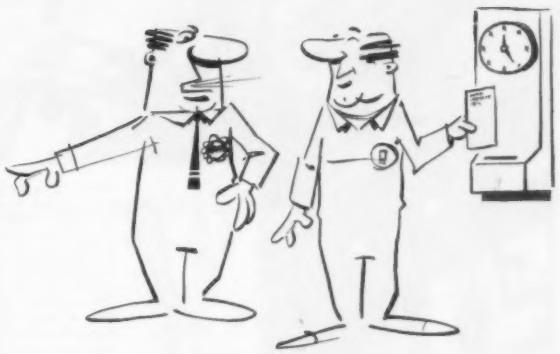
No. 2. Traffic Violation O.K. Discharge?

Walter Davis drove a truck. One morning while driving down a rough road, it began to rain heavily. He decided that, because the right side of the road was deeply pitted, he would take his vehicle on the left side. There was no traffic in sight, but on the left side there was a canal. Davis began to drive on the left side. The road collapsed and the truck plunged into the water. Davis climbed out, unhurt.

The employer decided Davis had been guilty of gross negligence and disobedience of a law. He was discharged.

Davis argued in his own defense:

1. I was not guilty of gross negligence. What happened was an accident. My judgement was bad, but it could have happened to anyone.
2. Yes, I violated the law, but that is not the employer's business, it's the state's.



The employer came back:

Davis was an experienced driver—knowing he should not disobey the law. He caused serious damage to our equipment, and we consider that gross negligence.

Test Yourself:

Was Davis: Right ☐ Wrong ☐

No. 3. Leaving the Work Site

Winston Lingar, who had six years seniority, went out in the middle of his shift to buy something, without asking permission. He was gone 25 minutes. When he returned he was fired. The company gave the following reasons:

1. We have had a rule for many years that employes who leave their jobs without permission can be discharged.
2. Violation of this rule has been getting serious and we have to crack down sometime.
3. You knew we were going to get tough because only last week we posted the following notice on the bulletin board:

". . . leaving the department without permission . . . during working hours must stop . . . According to our contract, leaving the premises while on duty . . . without permission . . . is cause for discharge."

The worker told the arbitrator:

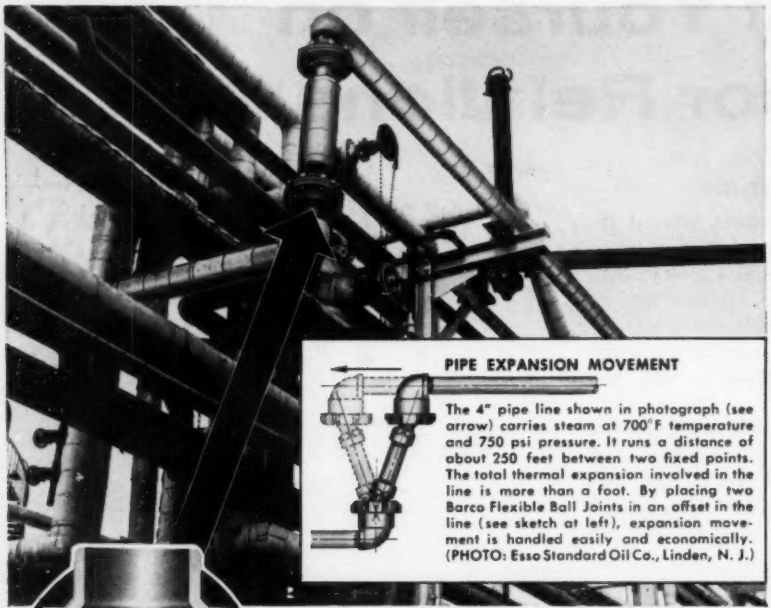
1. This rule has been violated for as long as I can remember. Therefore, it is ineffective.
2. I never saw that notice on the bulletin board. It was put up in another department.
3. No one said this rule was going to be enforced.
4. I'm not one to violate rules—I've got a good record here.

Test Yourself:

Was the employe: Right ☐ Wrong ☐

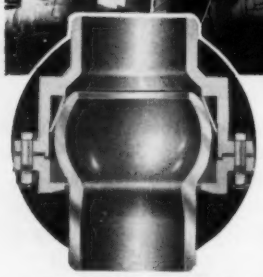
Answers on next page . . .

How Plant Handles 700°F. STEAM . . . PIPE EXPANSION



PIPE EXPANSION MOVEMENT

The 4" pipe line shown in photograph (see arrow) carries steam at 700°F temperature and 750 psi pressure. It runs a distance of about 250 feet between two fixed points. The total thermal expansion involved in the line is more than a foot. By placing two Barco Flexible Ball Joints in an offset in the line (see sketch at left), expansion movement is handled easily and economically. (PHOTO: Esso Standard Oil Co., Linden, N. J.)



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Test Yourself (Answers to Quiz on Page 223)

Arbitrator Robert L. Stutz ruled: "The basic question here is whether an employe may refuse to work a regular schedule of overtime because he has taken a second job, with conflicting hours. The answer to this question must be 'no.' While the Arbitrator is sympathetic with the problems of a man with a large family, it cannot accept Hernandez' refusal to work overtime. He was not being asked to work hours not required of other employes. Hernandez was discharged for just cause."

Arbitrator George D. Bonebroke ruled: The mere infraction of a traffic law does not permit an employer, in a contract such as this, to exercise discharge. Willfulness on the part of Walter Davis does not appear. Whether or not he acted reasonably, his conduct is not shown to be *willful*—that is, in a headstrong manner and in disregard of the consequences. The occurrence was an unfortunate accident—one that might have happened to anyone. It did not justify discharge for proper cause. The employe is to be offered full reinstatement."

Arbitrator Mark L. Kahn ruled: "Discipline must be consistent with past practice. The long-standing leniency which had existed should not be changed without discussion and notice to all employes. This kind of misconduct was generally condoned, at least at lower supervisory levels. It has been a practice for years for employes to leave premises without permission, and there was no company-wide or division-wide program for dealing with this. By virtue of its own inaction, the company is responsible for Lingar believing he could leave without permission and not get a serious penalty, even if caught. He is to be reinstated without back pay."

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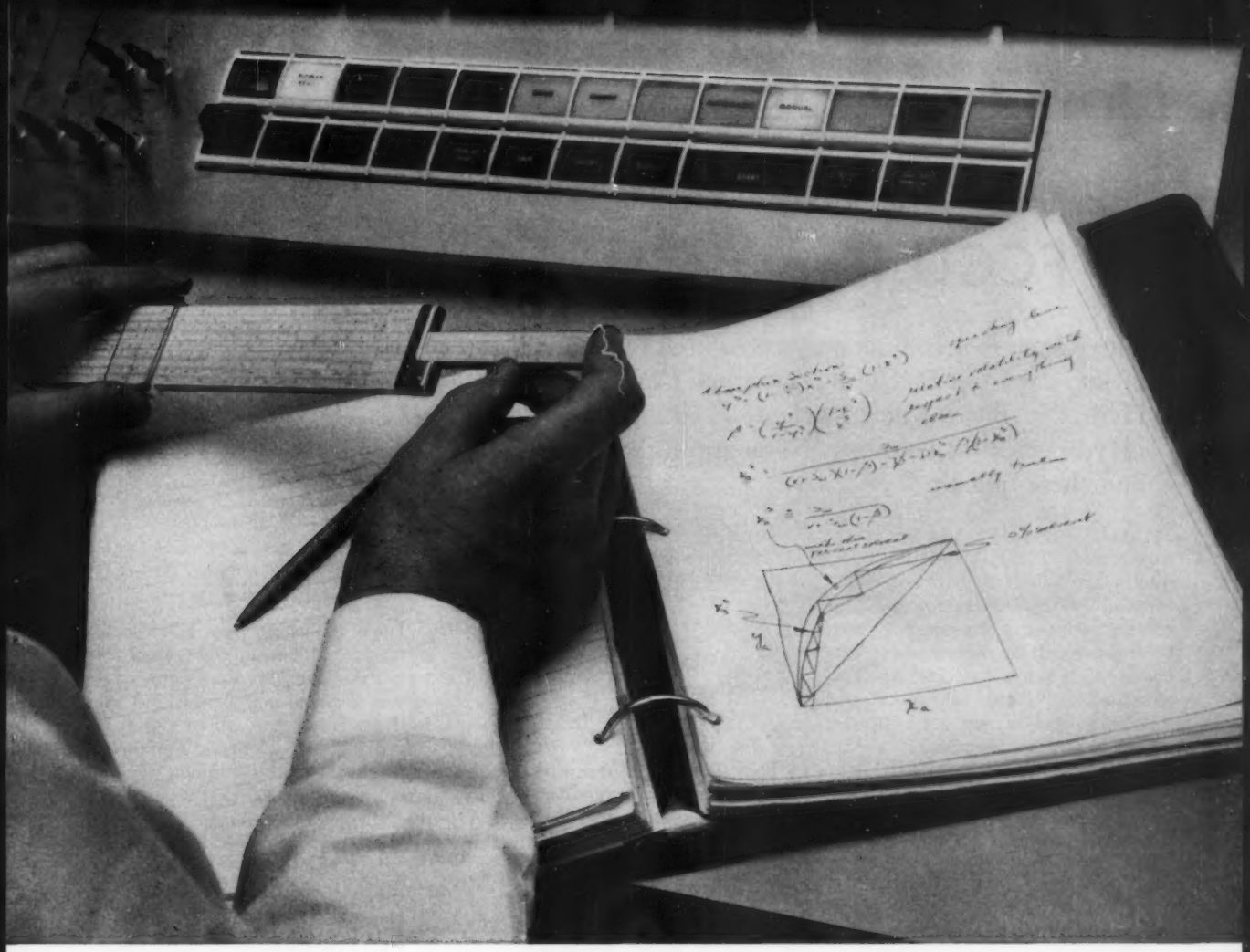

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***Here's what the Unit Operations Simulator does for you: 1.** Computation of (equilibrium constant). **2.** Computation of (temperature) from a given equilibrium constant. **3.** Computation of enthalpy of a vapor and/or liquid stream. **4.** Find equilibrium constant nearest unity. **5.** Computation of temperature from a given enthalpy of a vapor and/or liquid stream. **6.** Bubble point and dew point calculations. **7.** Split one stream into two at specified ratio. **8.** Mix two streams of same phase. **9.** A mixed feed adiabatic flash calculation. **10.** Adiabatic flash. **11.** Isothermal flash. **12.** Flash to a specified quantity of vapor. **13.** Absorber/stripper calculation using Edmister short cut.

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DATA PROCESSING

How to Do It...

Use Nomographs for Short Cuts to . . .

FCCU Regenerator Calculations

Three factors are commonly calculated from analysis of flue gas from FCCU regenerators: Carbon Burned, Hydrogen Burned and Percent Hydrogen in Coke (Hydrogen Plus Carbon). Nomographs will help you find these quickly

CALCULATIONS ARE frequently made using flue gas analyses (and usually air rate) to depict the performance of FCCU regenerators and reactor strippers. Nomographs have been developed to shorten these calculations, (Figures 1, 2 and 3). The equations are listed below and the following symbols are used in the equations for simplification:

X = Percent CO_2 + percent O_2 + ½ percent CO

Y = Percent CO_2 + percent CO

A = Air Rate, scfm

1. Carbon burned, pounds per hour = 1.501 YA/percent N_2
2. Hydrogen burned, pounds per hour = A(.133 — .5002 X/percent N_2)
3. Hydrogen in coke = $\dfrac{\text{Hydrogen}}{\text{Hydrogen} + \text{Carbon}}$
4. Or hydrogen in coke = $\left(\dfrac{0.266 \text{ percent } N_2 - X}{0.266 \text{ percent } N_2 - X}\right) + 3Y$

The above are commonly used equations except for number 4, which permits calculating the hydrogen in coke without knowing the air rate. In order to simplify the nomographs, an average percent nitrogen of 80.4 was assumed. This gives the following equations:

1. (a) Carbon burned, # per hour = .01867 AY
2. (a) Hydrogen burned, # per hour = A(.133 — .006221 X)
4. (a) Hydrogen in coke = $\dfrac{21.4 - X}{21.4 - X + 3Y}$

Table 1 illustrates the effect of assuming nitrogen different from the true value. It also shows the effect of two assumed inaccuracies in Orsat analysis. Number 5 where CO is assumed 0.2 percent below the correct value is the most common type of error in this work. This reveals that the effect of assuming an average nitrogen percent causes little error in

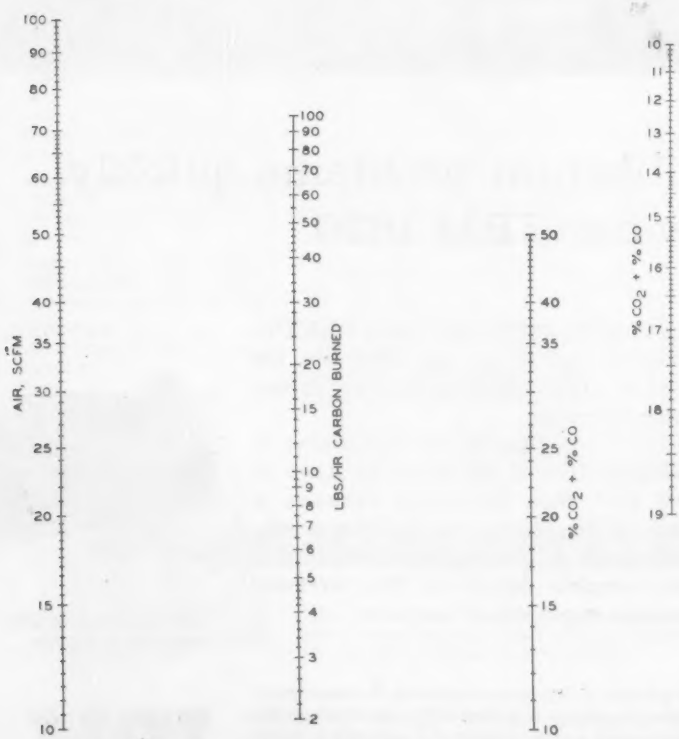


FIGURE 1—Carbon Burning Rate (Basis % Nitrogen = 80.4)

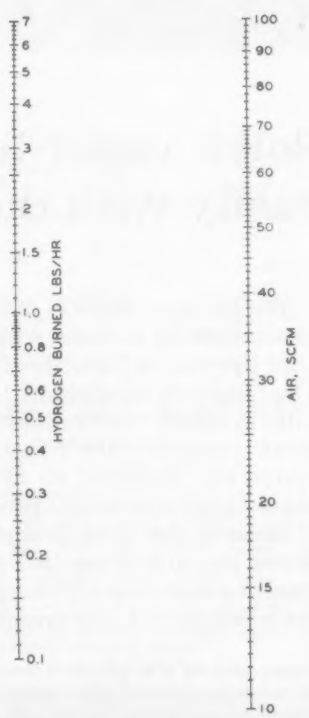
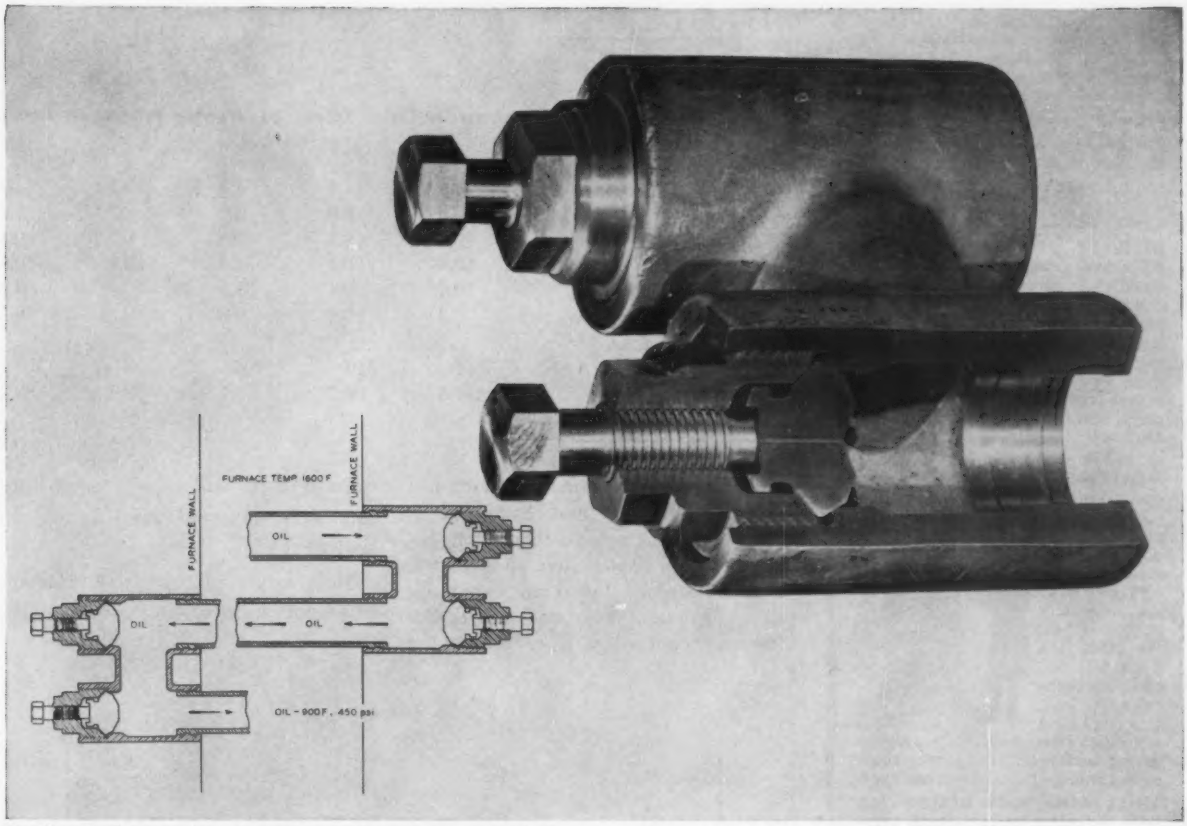


FIGURE 2—Hydrogen Burned (Basis 80.4 % Nitrogen)



Turning Back Corrosion: these U-shaped headers reverse oil flow through cracking furnace. Cast from nickel stainless steel, they're rugged, solid, heat- and corrosion-resistant, economically produced. Holding members are easily dismantled for tube cleaning.

One-piece design helps extend life

Cast stainless steel fittings handle hot sour crudes at 450 psi...last for years!

If you've had more than your share of replacement problems with fittings exposed to corrosion, and thermal and mechanical shock, perhaps you can profit from the example of Standard Oil Company of California.

They're Getting Years of Trouble-Free Service from header bodies like the ones pictured above, cast from corrosion-resistant nickel stainless steel. The fittings are used in a petroleum-cracking furnace at the El Segundo plant. It's tough service, making high-octane gasoline from highly corrosive California crudes, which pass through these headers at 900°F and 450 psi.

To Resist This Punishing Combination, the headers were ordered integrally cast of ACI type CF-8 stainless steel, containing 8-11 per cent nickel, 18-21 per cent chromium and a maximum of 0.08 per cent carbon. Strong one-piece design minimizes danger of leakage or rupture. Generous fillets and radii eliminate troublesome crevices, make maintenance simpler. Routine coke removal is simpler, too, thanks to a combination of simple design and corrosion-resistant surfaces.

Where Can You Use Such Performance? Stainless steel castings offer exceptional advantages for many applications in petroleum processing. They often permit better designs for fittings and other components subject to *multiple* attack from corrosives, high temperatures, heavy loading, and thermal shock. For detailed information, send for Inco's new booklet "Heat Resistant Castings, Corrosion Resistant Castings... Their Properties and Applications."

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JOHN E. POLIS
Senior Design Application Engineer of our Molecu-Dryer Division, reports on

LOW COST INSTRUMENT AIR DRYING

DELIVERY OF CLEAN, DRY AIR AT LOW COST for a "dry box" installation at one of our customer's plants . . . is now being accomplished with a Hayes MS Series Recirculating Molecu-Dryer. The same can be done for your instrument air system . . . where moisture causes rust, clogs up instrument ports, and creates freeze-ups in the air lines.

A NEW HAYES TYPE MSX MOLECU-DRYER has been developed to supply pure, dry air at −100°F and solve instrument air problems. An externally heated dryer, the MSX is a complete, compact, high-capacity unit featuring a simplified control system . . . makes drying and reactivating operations easy, automatic—at lowest cost ever.

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A WIDE SELECTION OF FLOW CAPACITIES and pressure ranges are available to meet your particular instrument air drying needs. Bulletin 1060C gives full details on the new Hayes Type MSX Molecu-Dryer. For your copy, write C. I. Hayes, Inc., 853 Wellington Ave., Cranston 10, Rhode Island.

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It pays to see Hayes for metallurgical guidance, lab. facilities, furnaces, atmosphere generators, gas and liquid dryers, pHayes-Master (TM) power controls.

How to Do It . . .

Table 1—Percent Hydrogen in Coke Effect of Wrong Nitrogen Basis

Case No.	1	2	3	4	5
CO_2, Mol %	11.1	11.1	11.1	10.9	11.1
CO, Mol %	8.0	8.0	8.0	8.2	7.8
O_2, Mol %	0.5	0.5	0.5	0.5	0.5
N_2, Mol %	80.4	80.4	80.4	80.4	80.6
Assumed Nitrogen	79.4	80.4	81.4	80.4	80.6
% H_2 in Coke	8.8	9.2	9.6	9.35	9.5
Carbon Burned, Lb/Hr (Per 10,000 scfm Air)	314	310	306	308	307
% of True Value	101.3	98.7	98.7	99.4	99.0

the carbon calculation. Calculation of hydrogen burned and hydrogen in coke are more sensitive to errors because of the subtraction involved.

It is assumed the nomographs are simple enough that sample calculations are not needed. Air rates and burning rates will usually be a hundred or a thousand times the figures shown.

Item submitted by K. A. Harper, Phillips Petroleum Corp., Bartlesville, Okla.

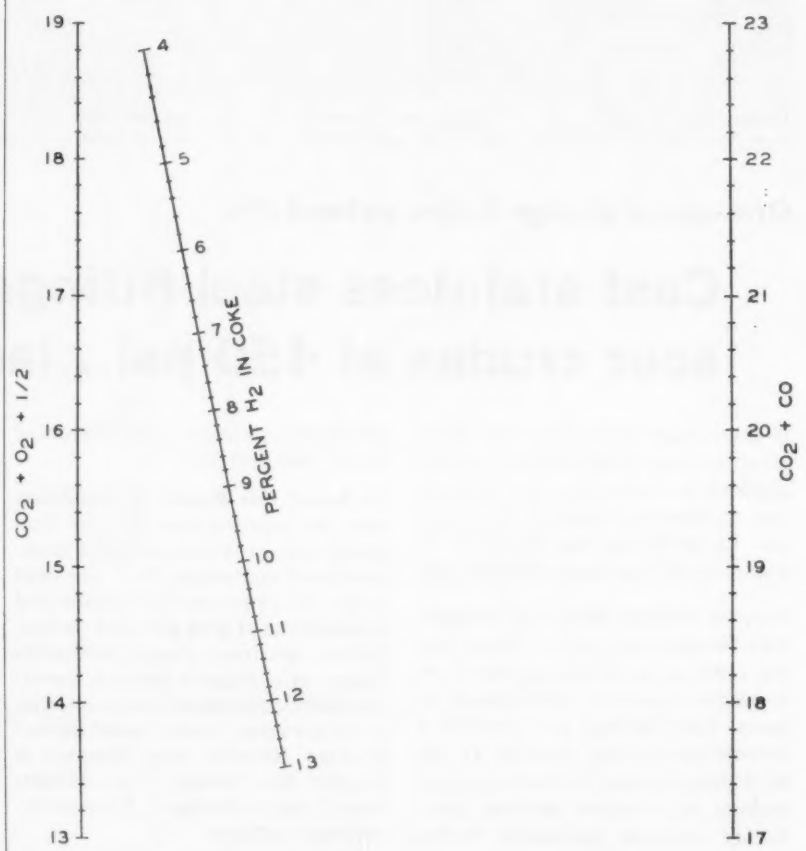
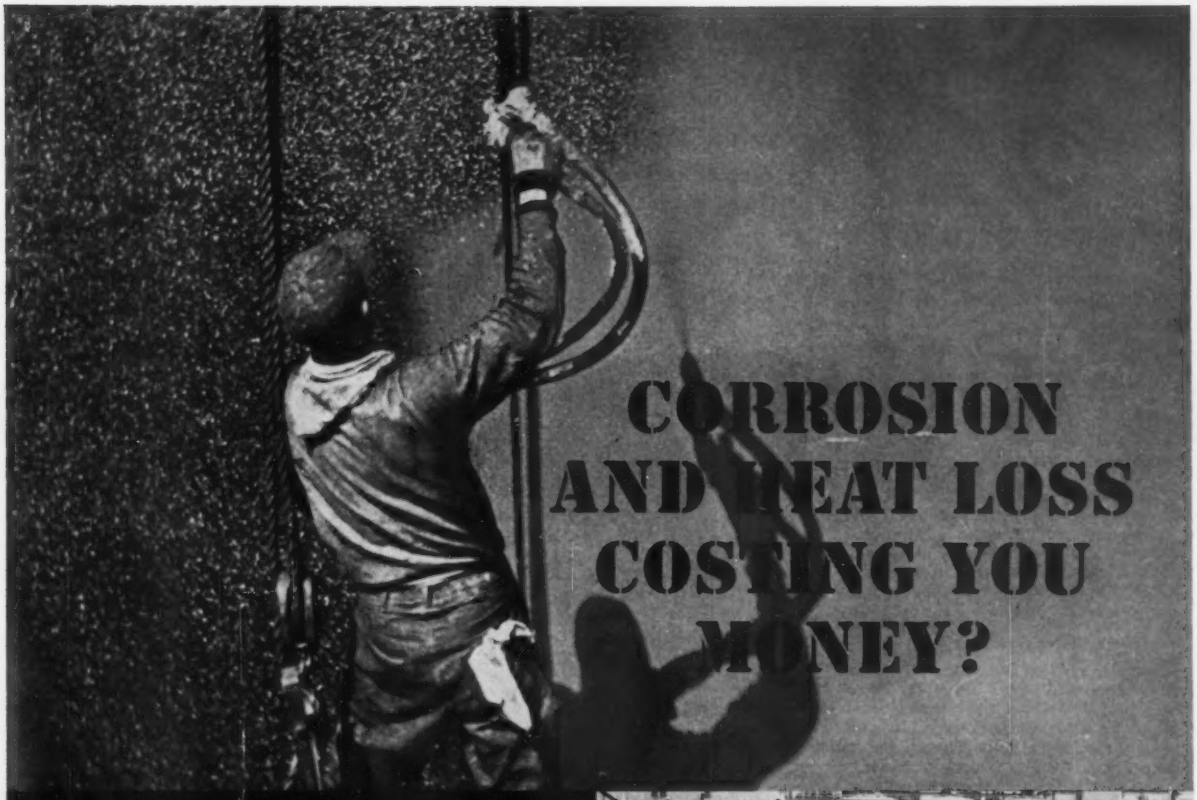


FIGURE 3—Percent hydrogen in coke from flue gas analysis

(Basis: 80.4 percent nitrogen in flue gas)



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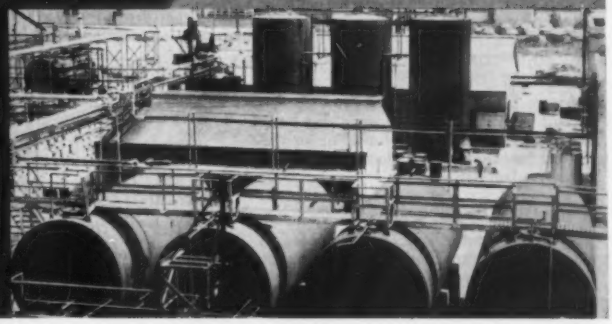

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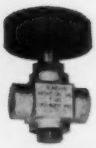

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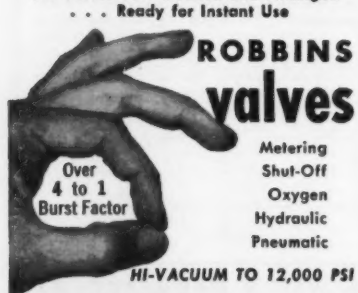

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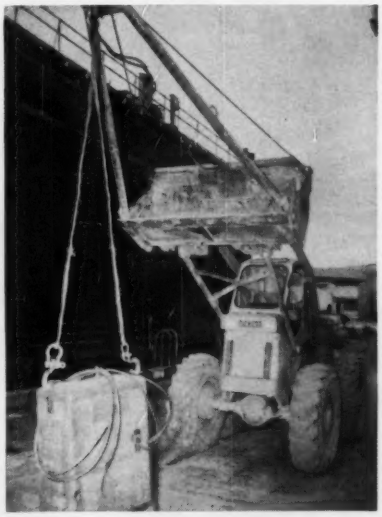
How to Do It . . .

Removable Boom Makes Crane Out of Bucket Loader

One refinery maintenance superintendent installed a boom on the front of his front-end loader and uses it to move equipment inside the plant. It is attached with four bolts, two at the bottom to hold the ends of the



boom and two at the top for the guy lines, and can be removed in a matter of moments if there is dirt to be handled. Since the bucket on the loader is designed to move through several feet, there is no need to have a sheave or winch on the tractor. Loads up to one ton can easily be lifted, transported and spotted in full view of the operator.

YOUR IDEAS ARE VALUABLE!

At least $10 will be paid for each idea accepted for "How to Do It." Just send a brief note with a photo or sketch to the Editor, *Petroleum Refiner*, P. O. Box 2608, Houston.

ANOTHER NEW ACHIEVEMENT IN MODERN FLOW CONTROL BY CRANE

1. Single retaining nut holds cartridge assembly in body, for fast, foolproof dismantling and assembly
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* Teflon is a registered trademark of E.I. DuPont de Nemours & Co., Inc.

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with the exclusive tapered cartridge that drops out for fast, in-line servicing

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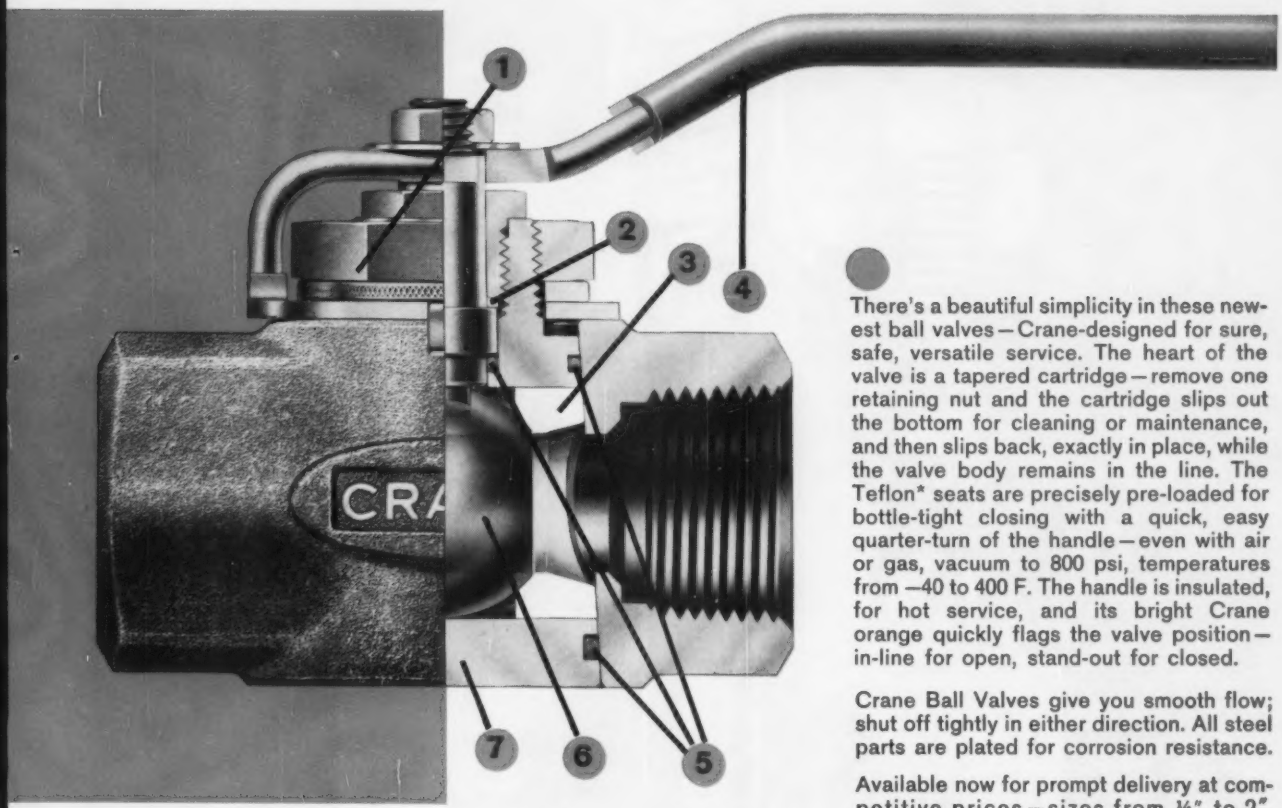

There's a beautiful simplicity in these newest ball valves—Crane-designed for sure, safe, versatile service. The heart of the valve is a tapered cartridge—remove one retaining nut and the cartridge slips out the bottom for cleaning or maintenance, and then slips back, exactly in place, while the valve body remains in the line. The Teflon* seats are precisely pre-loaded for bottle-tight closing with a quick, easy quarter-turn of the handle—even with air or gas, vacuum to 800 psi, temperatures from —40 to 400 F. The handle is insulated, for hot service, and its bright Crane orange quickly flags the valve position—in-line for open, stand-out for closed.

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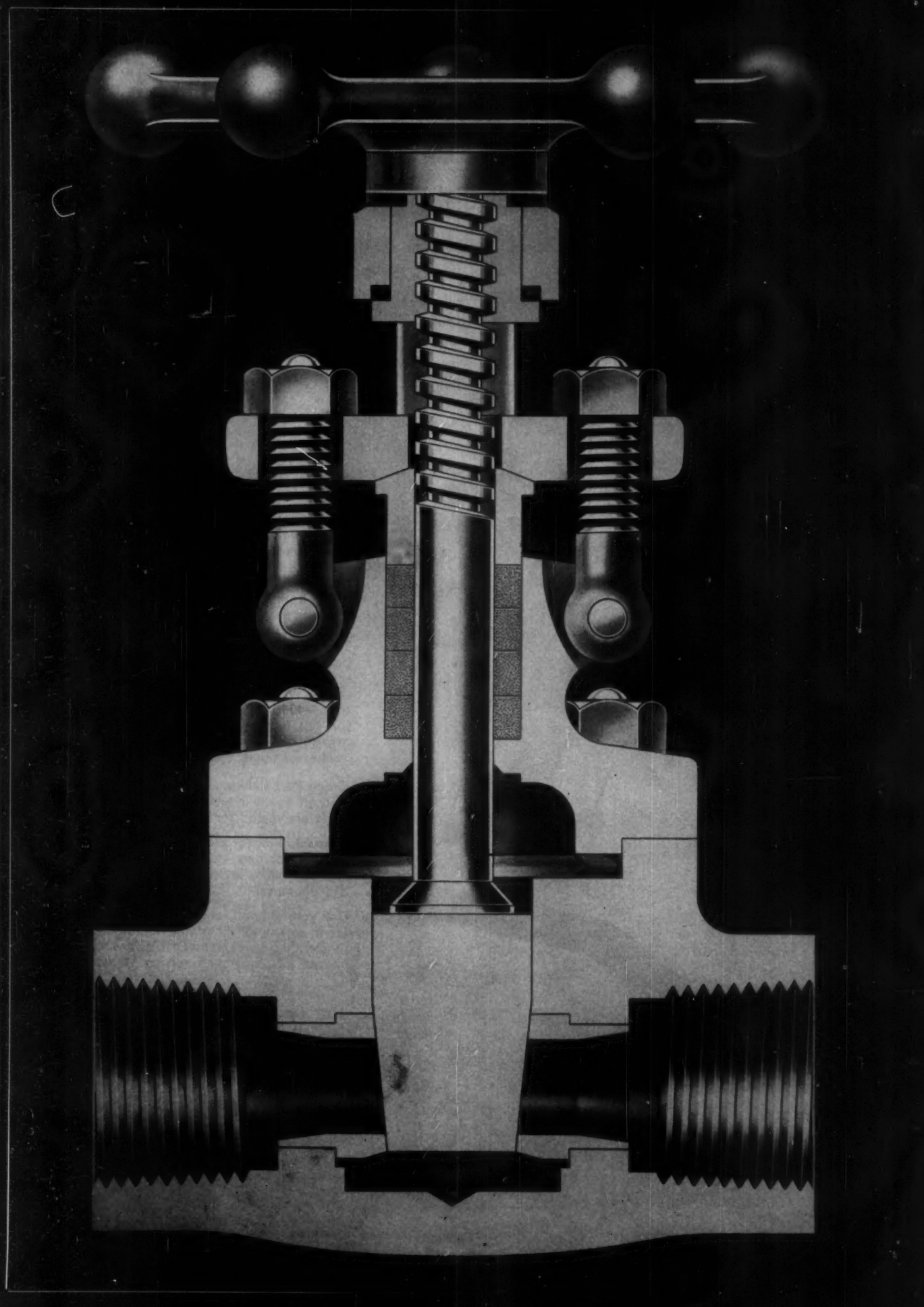

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Who's Building in HPI...

New Process Slated for Celanese Plant

Acetaldehyde will be principal product of the plant, which will cost $12 million

CELANESE CORP. OF AMERICA will become the first U.S. company to make chemicals from petroleum resources by a new European process. The new process will be used at a multi-million-dollar plant to be built on a 1,000-acre site near Bay City, Texas.

Construction will start in the second quarter of 1961 and will be completed within a year. The facility, which will cost about $12 million, will have a capacity of 100 million pounds per year of chemicals by blasting air through the by-product ethylene.

The process to be used provides a new route for the economical manufacture of acetyls, a family of widely-used chemicals formed by certain combinations of oxygen and petroleum gases. Celanese currently makes 30 chemical derivatives of the acetyl family, with annual production exceeding 500 million pounds.

The new process involves the combination of oxygen with ethylene gas in the presence of a catalyst (a substance promoting chemical reactions). Oxygen is as abundant as air itself and ethylene is produced in large quantity from vast petroleum resources in the region of the Bay City plant site.

The principal product to be made by the new process at Bay City will be acetaldehyde, the starting point for the production of many other acetyl chemicals. The new plant's production will back up current acetaldehyde manufacture by other processes at two existing Celanese chemical plants in Bishop, and Pampa, Texas.

Initial facilities at Bay City also will include units for the making of 2-ethyl hexanol, the latest addition to the Celanese line of acetyls. Manufacture of 2-ethyl hexanol, currently conducted at Bishop, will be transferred to Bay City as soon as the new facilities are completed.

Celanese uses 2-ethyl hexanol for making synthetic jet lubricants at a third existing chemical plant in Point Pleasant, W. Va. The company also uses the chemical in the manufacture of 2-ethyl hexyl acrylate at Pampa.

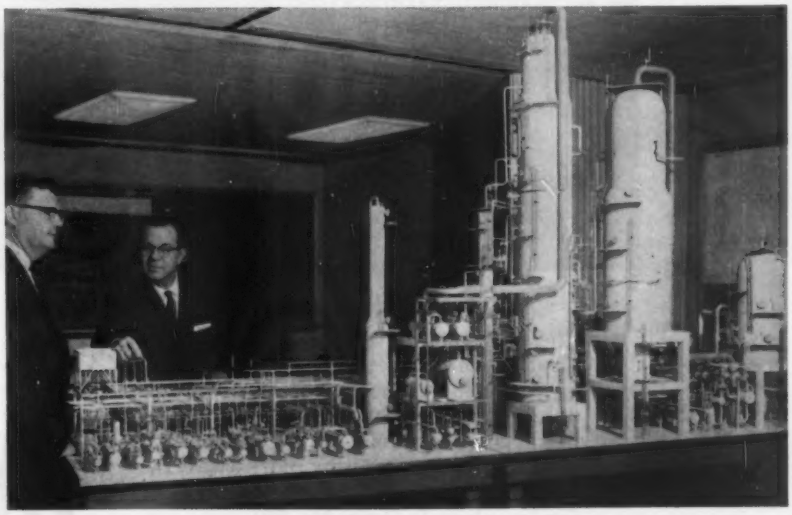
Total current Celanese production of basic chemicals from petroleum resources exceeds 1 billion pounds per year. In addition to the acetyl chemicals, the company makes many derivatives of formaldehyde and methanol.

Suntide Refining Co. has completed a hydeal unit at its refinery in Corpus Christi, Texas. Plans have been made to start building a styrene unit in August or September with on stream date in one year. Badger Manufacturing Co. is finishing the design on an ethyl benzene unit at the plant.

Collier Carbon & Chemical Corp., a Union Oil Co. subsidiary, has begun converting refinery by-products at its new plants adjacent to Union's Los Angeles and Oleum refineries. The new Los Angeles plant has a 250-ton-per-day capacity for converting spent alkylation acid, hydrogen sulfide and sulfur into sulfuric acid. Adjacent to the Oleum refinery, Collier has begun operation of a $2-million plant to use Union's petroleum coke and other raw materials. This plant converts "raw" or green coke, a refining by-product, into high grade calcined carbon.

Enjay Chemical Co. will expand its ethylene producing capacity of its Bayway, N.J., refinery by 35 percent. The plant's ethylene capacity will be 175 million pounds per year when expanded facilities are completed in the second quarter of 1962. The increase will raise the company's total ethylene producing capacity to approximately 845 million pounds per year. Preliminary construction work for the Bayway project is already underway.

Hunt Oil Co. will build a gas processing plant near McGregor, N.D. The $2-million refrigerated-absorption-type facility will handle 10,000 MMcfd of gas coming from the North Tioga and McGregor fields. The plant will have a capacity of 15,000 gallons of propane, 10,000 gallons of butanes, 8 long tons of sulfur, and 7,000 gallons of natural gasoline daily.



Construction has begun on DX Sunray Oil Co.'s new multi-million-dollar crude oil distillation unit at its Tulsa refinery. Harry A. Brown, left, vice president of manufacturing, and T. L. Tiernan, manager of the Tulsa refinery, inspect a scale model of the new unit, which will have a capacity of 85,000 bpd. Among the unique features of the unit are a furnace with a heating capacity of more than 300 million Btu's per hour and hot water cooling system for the asphalt product. (Petroleum Refiner, Vol. 39, No. 9, Page 362.)

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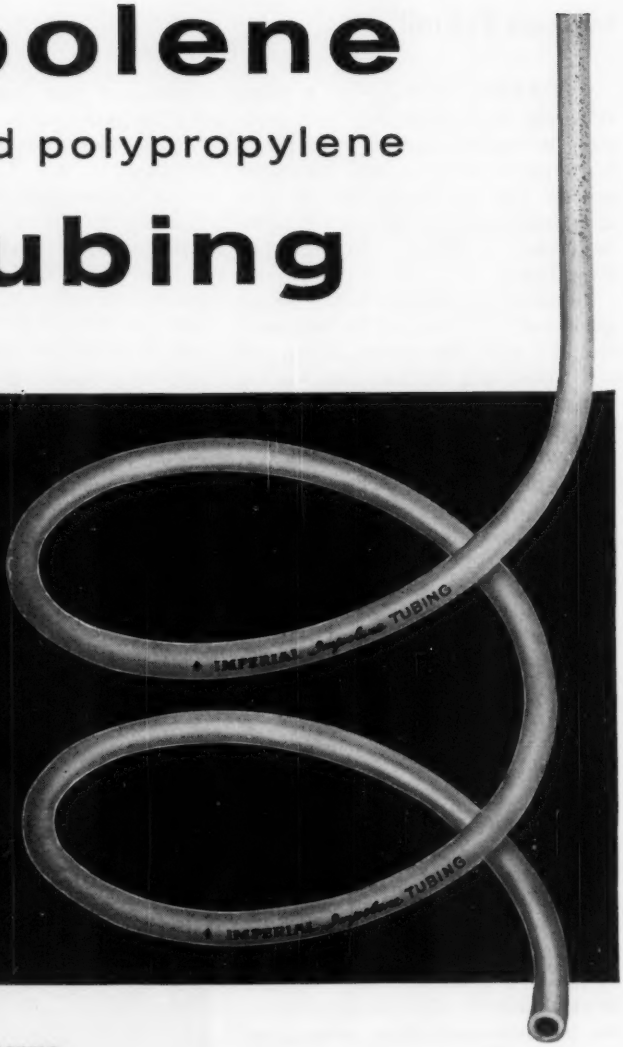

The introduction of Impolene thermoplastic tubing foretells major improvements in the transmission of air and fluids. This Imperial-Eastman stabilized polypropylene tubing now has many proved uses. Many more await it. What's yours? For complete data, write for Impolene Bulletin No. 301.

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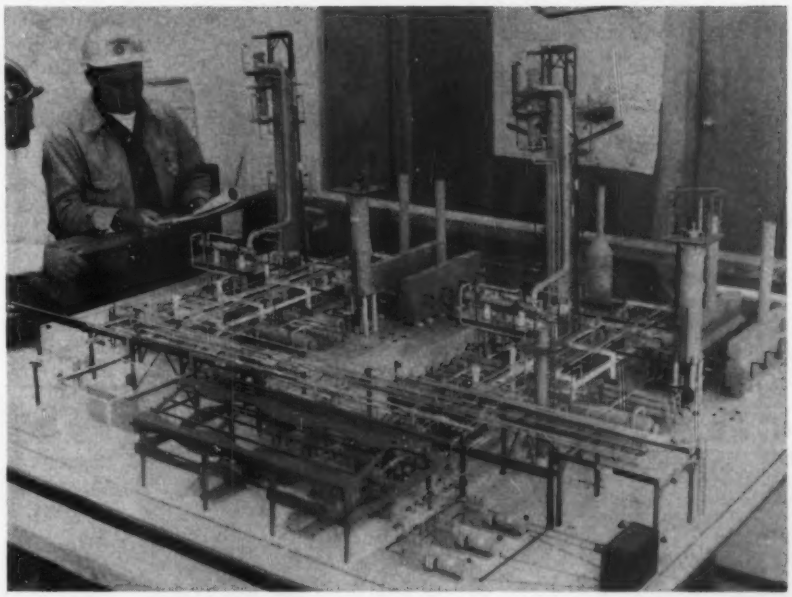


A precise scale model is simplifying construction of Gulf Oil Co.'s new unit for processing lubricating oils at its Port Arthur, Texas, refinery. The model, located only a few steps from the job site, made the use of many conventional drawings unnecessary. In addition, operating crews will use the model to familiarize themselves with the unit's operation prior to scheduled start up in the spring. The new lube oil facility will consist of a pair of identical units, each with a daily capacity of 6,500 barrels. Highly flexible, the installation will be able to handle 12 different feed streams from existing operations. (Petroleum Refiner, Vol. 39, No. 11, Page 206.)

Hercules Powder Co. has completed an expansion program at its Hercules, Calif., plant. The facility, after expansion, has yearly capacities of 8 million gallons of methanol, 50 million pounds of formaldehyde, and 11,000 tons of urea-formaldehyde compositions.

Olin Mathieson Chemical Corp. is expanding its Chemicals Division's plant at Doe Run, Ky. First unit to go into production under the current $20-million expansion program was the ethylene dichloride unit in September 1959. Construction of a new direct oxidation unit to produce ethylene oxide is complete, and ground is being broken for a new glycerin plant, scheduled to start production early in 1962. Other units being expanded are propylene glycol, ethylene fractionation, glycol ether, and a steam plant.

United Carbon Co. has purchased a 45-acre tract, 85 miles north of Los Angeles, for a new carbon black plant with initial capacity of 64 million pounds yearly. Construction of the plant is scheduled for completion within 10 months and production is expected by late 1961. The contract for engineering and construction has been awarded to Lummus Co., Houston. United Carbon domestically produces more than 1 million pounds of carbon black per day.

National Distillers and Chemical Corp. will begin construction this spring of a 60-millon-pound-per-year linear polyethylene plant adjacent to the company's conventional polyethylene plant at Houston. The new plant, which will mark National's entry into the manufacture of linear polyethylene, is scheduled for completion in the fourth quarter of 1962. National Distillers and Chemical's present facilities for conventional polyethylene have a rated capacity of 300 million pounds annually.

The Pure Oil Co. and The Atlantic Refining Co. are expanding benzene facilities at Pure's Nederland, Texas, plant. Benzene capacity will be 50 million gallons annually. Completion is set for December.

Aurora Gasoline Co., subsidiary of The Ohio Oil Co., is expanding its Detroit refinery to provide The Dow Chemical Co. with about 20 million gallons of benzene-toluene mixture annually, starting in mid-1962. Engineering work is underway on the multi-million-dollar

For more data on advertised products, use Readers' Service Cards, last page.

Building . . .

project, which will be Michigan's leading supplier of petroleum-derived benzene. The high-purity benzene-toluene mixture will be shipped by pipe line to Dow's Bay City, Mich., plant for conversion to pure benzene.

Hercules Powder Co. is building a second polyolefins unit at its Lake Charles, La., plant. When the installation is completed, sometime early in 1962, Hercules will have capacity to produce 200 million pounds per year of polyolefins. The company is currently making polypropylene and polyethylene at an 80-million-pound-per-year plant at Parlin, N.J.

Allied Chemical Corp. is constructing a battery of 60 by-product coke ovens at its Niagara River Road plant in Tonawanda, N.Y. The new ovens will replace one of the two existing batteries at the plant. Dismantling work on the battery to be replaced will start in March, and it is expected that the new battery will be completed by the end of 1961.

Honolulu Oil Corp., Taft, Calif., has built a unit for the production of liquid carbon dioxide at one of its natural gasoline treating plants. Initial capacity will be 25 tons per day.

Humble Oil & Refining Co. has begun construction of alcohol facilities at its Baton Rouge, La., refinery. Humble is expanding its oxo unit to produce 30 million pounds per year of specialty alcohols. Refinery mechanical personnel are handling construction at a cost of $4 million.

Monsanto Chemical Co. has started supplying commercial quantities of nonyl phenol and dodecyl phenol from its Kearny, N.J., plant. The products, manufactured in recently completed alkyl phenol facilities at Kearny, are widely used as intermediates in the manufacture of nonionic surfactants and are used to some extent in rubber chemicals and motor oil additives.

Oxo Chemicals Co. plans to construct a multi-million-pound-per-year isooctyl and decyl alcohol plant at Haverhill, Ohio. The plant will occupy about 20 acres of a much larger company-owned site fronting on the Ohio River. Construction of the unit began in January with completion scheduled for early 1962. Oxo Chemicals is owned by Pittsburgh Chemical Co., Pittsburgh, and Amoco Chemicals Corp., Chicago.

Texaco, Inc., has started construction of a 12,000-bpd kerosine hydrotreater at its refinery in Port Arthur, Texas. Construction of the unit began in January and is scheduled for completion in mid-1961. The hydrotreater will remove sulfur from a kerosine feed stock. Fluor Corp., Ltd., has been awarded the contract for design, engineering, purchasing and construction.

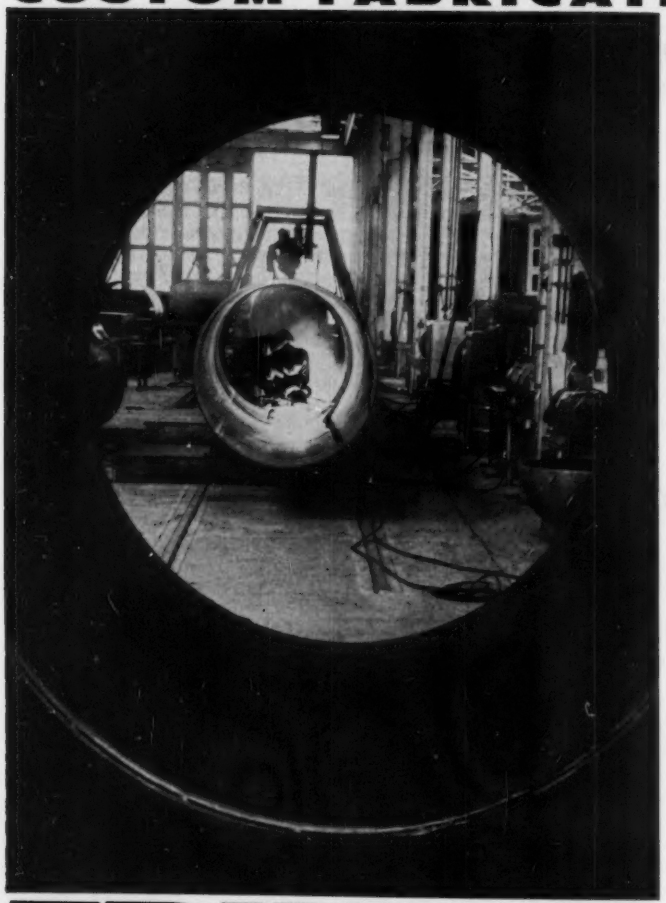
Texas Eastman Co. has begun large-scale production of polypropylene in Longview, Texas. By mid-year the plant will achieve a capacity of 20 million pounds annually. The facility, which also produces polyethylene, is located in the heart of the propane-rich gas fields of Eastern Texas. Serving the factory are two separate cracking plants.

Celanese Chemical Co. has completed a multi-million-dollar expansion of acrylate esters production at its Pampa, Texas, plant. Facilities at Pampa are designed for annual production of 14 million pounds of butyl and 2-ethylhexyl acrylate and glacial acrylic acid. Including earlier units for making methyl and ethyl acrylate, the plant currently has an overall acrylate capacity of 30 million pounds per year.

Union Pacific Railroad has begun construction on a natural gasoline plant at Patrick Draw oil and gas field, Sweetwater County, Wyo. Cost of the facility is estimated at $3 million.

Mobil Oil Co. has completed an addition to its Hickock gas plant in the Kansas Hugoton field. The new facilities consist primarily of two 880-horsepower compressors, installed to maintain deliveries of natural gas to Cities Service Gas Co. The two compressors will compress gases from 275 pounds to 300

CUSTOM FABRICATION



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YARWAY news briefs

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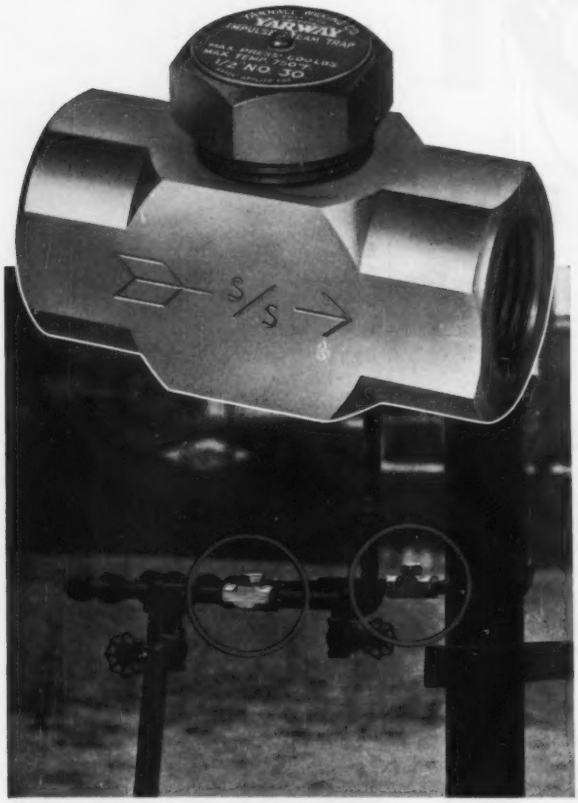
YARWAY SERIES 30 IS THE STEAM TRAP FOR PEAK EFFICIENCY



Two Yarway Series 30 traps on tracer lines from a loading station to polystyrene storage tank at the Midland Division of The Dow Chemical Co., Midland, Mich. Steam pressure is 150 pounds.

on tracer lines, main drips, meter boxes and other steam equipment

Yarway Series 30 Impulse Steam Trap has won enthusiastic acceptance and scored outstanding success on those hundreds of applications where condensate is handled in moderate amounts. Here's why:

- Economy of operation, with closer condensate control
- Longer service life, with lever action reducing impact on valve seat
- Lower maintenance, with easily and quickly replaceable seat and disc
- High quality, all stainless steel—combined with a new low cost

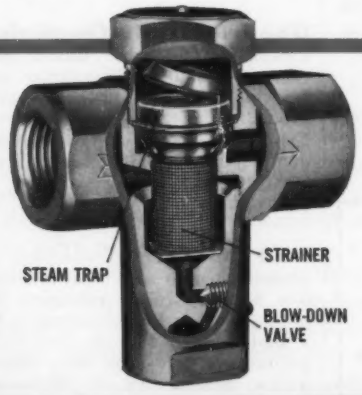
Here are a few typical user experiences:

TEXAS REFINERY—*Been using ½" No. 30's on drip legs to steam lines for 6 months. "No troubles whatsoever."*

PENNSYLVANIA TIRE MFR.—*Gradually replacing all traps on tire molds with Yarway No. 30's. "Amazed at their performance."*

MISSOURI STEEL PLANT—*Tested Yarway No. 30's against competitive traps, with result "Yarway No. 30 now standard on all main steam header drips."*

So it goes in plant after plant. Why don't *you* try Yarway Series 30 Traps? Available in ⅜" or ½" size; pressures 8 to 600 psi. Your nearby Industrial Distributor carries them. Write for his name.



NEW! COMPACT COMBINATION

NEW SERIES 130 steam trap combines a Series 30 trap, a strainer, and blow-down valve *all in one compact unit*—with these advantages:

- Saves space
- Saves installation costs
- Saves weight
- Saves on maintenance

Stainless steel construction, good for all pressures 8 to 600 psi.

Your Yarway distributor has SERIES 130 traps. Try one today—or write for new Bulletin T-1743-B.

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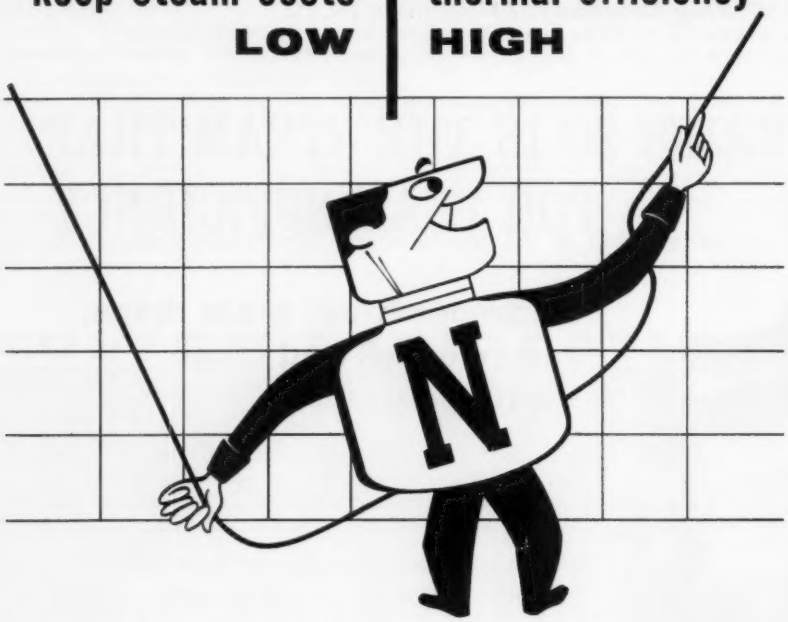
Nicholson Thermostatic Steam Traps

keep steam costs LOW | thermal efficiency HIGH



Low costs and high efficiency! Nicholson Traps give you both . . . by *design*. And here's how. Hardened stainless steel seats and valves are accurately lapped for sure, tight shut-off . . . so, there is no waste of live steam. True balanced pressure . . . the operating principle of these valves . . . assures fast intermittent discharge of condensate and air, resulting in maximum thermal value from every pound of steam produced.

As for capacity, these traps *really* have it . . . up to six times greater than ordinary traps. Maintenance? Practically none, for there is only one moving part. No links no pins. No pivots or levers. No adjustable orifices to stick or clog.

Sure, some traps cost less than Nicholson . . . but the 'savings' exist only on the invoice. In actual use, some other traps can cost you three or four times their price in annual steam waste. Be sure to weigh cost against value when *you* buy steam traps. Specify Nicholson Thermostatic Steam Traps on your lines and equipment.

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Building . . .

pounds, with a delivery capacity of 100 MMcfd. Bowden Construction Co., Odessa, Texas, are the contractors.

Celanese Corp. of America is planing to build a multi-million-dollar polyformaldehyde plant in Bishop, Texas, 40 miles south of Corpus Christi. Brown & Root, Inc., Houston, has been awarded the construction contract. The facility will be started this year.

Stepan Chemical Co. will begin making tetraethyllead and tetramethyllead at a new plant, details to be announced later. Societa Lavorazioni Organiche Inorganiche, an Italian producer of antiknock gasoline additives, will provide design data and process information and train Stepan personnel.

E. I. du Pont de Nemours & Co. is expanding methanol production at its Sabine River Works, Orange, Texas. This will increase Du Pont's methanol capacity by 35 percent. Completion date is set for late 1961.

Monsanto Chemical Co. is increasing its vinyl chloride monomer capacity at Texas City by 50 percent. This will boost the plant's capacity to 150 million pounds per year by July 1.

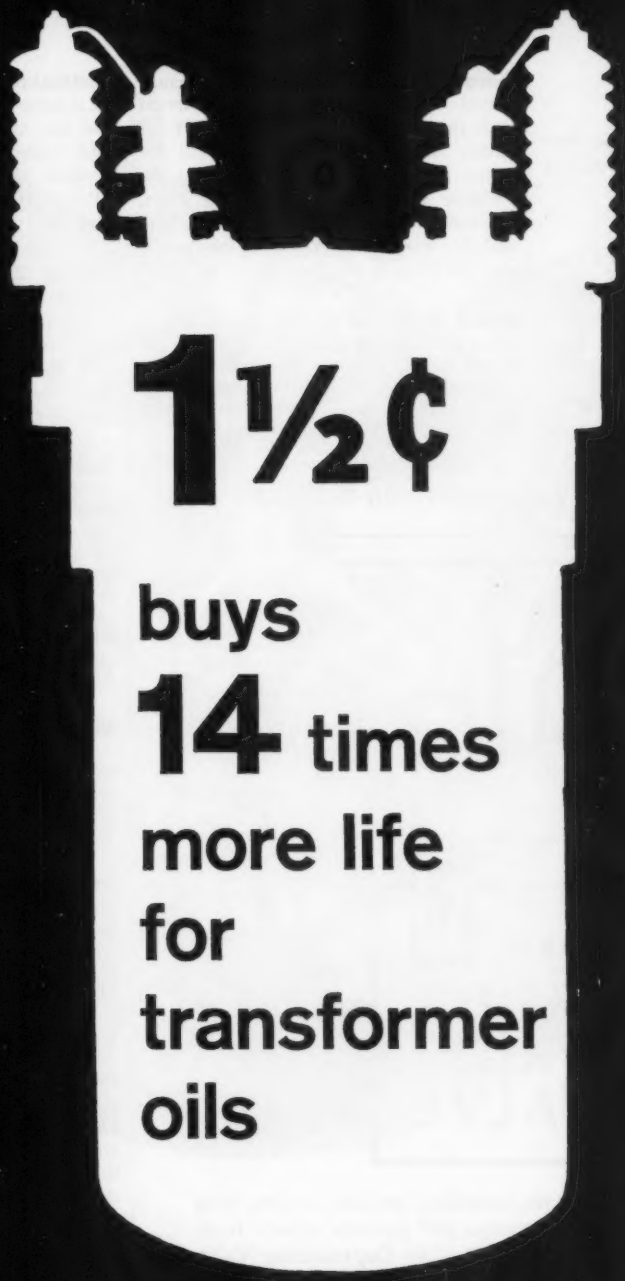
Diamond Alkali Co. is planning a multi-million-dollar ammonia works plant at its Deer Park, Texas, facilities on the Houston Ship Channel. The plant, which is in the preliminary engineering stages, is expected to be started within three or four months.

Hooker Chemical Corp. is increasing the chlor-alkali capacity at its Niagara Falls, N.Y., plant, planned for operation in mid-1961. Conversion from 25 to 60-cycle power at the facility will be 85 to 90 percent complete by next June.

Goodrich-Gulf Chemicals, Inc., Cleveland, Ohio, has started construction of a multi-million-dollar plant at Institute, W. Va., for the commercial production of cis-polybutadiene rubber. Expected to be in operation by the end of this year, the initial unit will start up with an output of 20 million pounds annually.

Shell Oil Co. will complete a conversion program soon of its benzene facilities at three of its refineries. Benzene production has been enlarged to provide a total capacity of more than 60 million gallons per year. The three plants producing benzene are at Wilmington, Calif., Houston, and Wood River, Ill. A

For more data on advertised products, use Readers' Service Cards, last page.



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Transformer insulating oils inhibited with DBPC® antioxidant assure utility companies of longer, more effective protection of transformer parts. DBPC antioxidant inhibits the oil against oxidation, prolonging its useful life by preventing the formation of sludge deposits. Years of performance show that new transformer oils treated with DBPC antioxidant serve 14 times as long at a cost of only 1½¢ more per gallon. The result is superior protection of transformer insulation and reduced costs for maintenance and oil changes.

DBPC is not only low in cost, but it produces no detrimental side effects. It is easily and safely handled and requires only dissolving in the transformer oil. Its basic stability and long-range protection have served most of the oil refiners.

Koppers DBPC is also used by refiners in stabilizing other petroleum products such as gasoline, plastics, waxes, industrial fats, greases and industrial oils. For more information on using DBPC for your needs, write: Koppers Company, Inc., Tar Products Division, Pittsburgh 19, Pa.

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Building . . .

large portion of Shell benzene production will be consumed by Shell Chemical Co. in its manufacture of styrene.

Plymouth Oil Co. has awarded a contract to Procon, Inc., to construct petrochemical facilities at Plymouth's Republic Division refinery in Texas City. Total cost will be about $2.5 million. Construction has already started with completion set for July 1961.

Amoco Chemicals Corp. has completed trial runs and is fully on stream with its new polybutene plant at Wood River, Ill. The new facilities will increase Amoco's capacity 60 percent. In addition to the Wood River facilities, polybutene is made at the Yorktown, Va., and Eldorado, Ark., refineries of American Oil Co.

Mobil Chemical Co. has purchased 14 acres in Edison Township, N.J., on which it will erect a research and development facility. Mobil Chemical also has a branch research and development laboratory in Beaumont, Texas.

Continental Oil Co. has awarded a $2.2-million contract that will double the size of its main research laboratory and cover construction of a research services building at Ponca City, Okla. (PETROLEUM REFINER, Vol. 39, No. 8, Page 169.)

Crown Central Petroleum Corp., Baltimore, Md., is constructing a major petrochemical complex at its refinery on the Houston Ship Channel. The plant will make high grade benzene, xylenes and toluene. Completion and operation is set for October 1961.

Gulf Oil Corp. is planning a multi-million-dollar benzene plant at its Girard Point refinery. This is in addition to the new oxo-alcohol plant which has been completed and will shortly be placed in operation. The company has still other plans for the expansion of its petrochemical facilities at Girard Point which are expected to bring the total investment at that location to more than $20 million in 1960 and 1961.

Monsanto Chemical Co. is boosting its high-pressure polyethylene capacity by 30 per cent. The expansion has already begun at Monsanto's Texas City plant and will be completed early next year.

Dow Chemical Co. will build a second polyolefin plant at Plaquemine, La., to be completed in the second quarter of 1962. The plant will make medium and high-density polyethylene and ethylene copolymers and polypropylene. One such facility at the Louisiana Division began producing in December.

Humble Oil & Refining Co. has started operating a new asphalt still at its Bayonne, N.J., refinery. Three crudes were run for seven different products during the initial run. Sub-freezing weather during January delayed start up of the two-stage unit.

Borden Chemical Co. and United States Rubber Co. has awarded Chemical Construction Corp. a contract for an 80-million-pound-per-year acetylene plant at Baton Rouge, La. The plant will use the Badische Anilin & Soda Fabrik partial oxidation process.

American Cyanamid Co. will build a multi-million-dollar methacrylate plant at Fortier, La. The facility, which will be on stream in two years, will have a 30-35-million-pound-per-year capacity. Imperial Chemical Industries has granted Cyanamid a license.

Hartol Petroleum Corp. has begun construction of a 350,000-barrel refined petroleum products storage and distribution terminal at Norfolk, Va. Hartol is a subsidiary of Tennessee Gas Transmission Co., Houston.

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Tank pressure holds valve "A" closed. Releasing pressure in line "B" by any means opens valve instantly – venting through port "C" to atmosphere or to discharge system.

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DEPRESSURING SAFETY VALVE

Now . . . a depressuring valve with simplified positive action, long needed to protect pressure type storage and process vessels from failure due to exposure fire! S&J Model 4280 Depressuring Valve is designed to minimize the problem of exposure fire by affording venting as outlined in API RP-520. This valve is energized by pressure in the protected vessel, and opening will always occur if pressure above the disc is relieved by any means. It may easily be instrumented for remote opening and closing. For service in corrosive environments, this S&J product may be specified in carbon or alloy steels. S&J research and development have paid off again—with safety dividends for you! Get the facts from your nearest S&J office, or write for detailed information.

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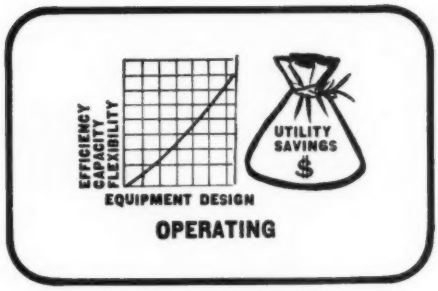

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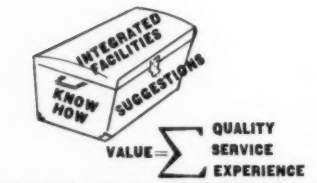

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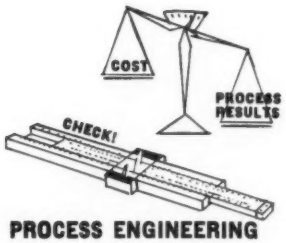
The cost/value ratio of Glitsch Ballast Trays and other fractionating equipment is good because of their large turn-down ratio, excellent efficiency, and good capacity.

Low pressure drop and good efficiency over a wide range of operations save many dollars in utilities!



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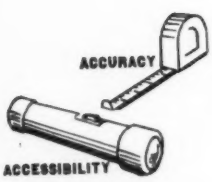

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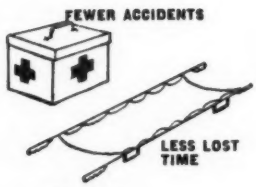

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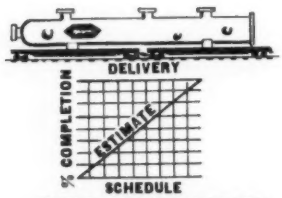

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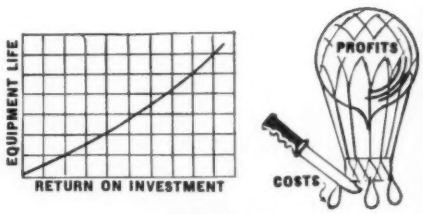

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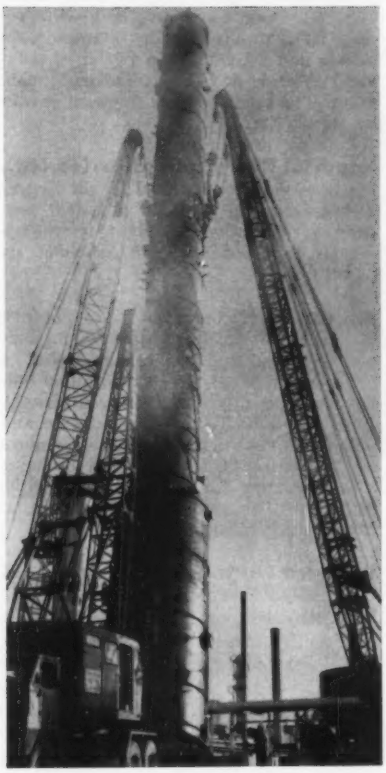

GOING UP! I took three gaint mobile cranes only 30 minutes to hoist a ponderous, 59-ton "stripper" tower, 150 feet in length, into position at British American Oil Co.'s Montreal East refinery. The tower is part of a $2.5-million aromatics extraction plant currently under construction. Prime product of the plant will be benzene.

SunOlin Chemical Co. is building a $20-million ethylene plant at Claymont, Del. The project will be completed by the end of 1961.

Amoco Australia, Ltd., plans to build a refinery near Brisbane, Australia, with a crude capacity of 15,000 bpd. Refinery products will be gasoline, kerosine, diesel fuels, fuel oils, and others for sale in Australia. Amoco Australia is a subsidiary of Standard Oil Co. (Indiana).

Sicily's Assessorat of the Industry has extended the construction completion date on the Milazzo refinery to March 1962. A new company has been formed in Palermo, Sicily, to build a refinery with American and Swiss capital.

American Independent Oil Co. has been granted an extension of its option to build a refinery in Rhodesia and Nyasaland. The extension is to allow American Independent to submit further data requested by the government. The Rhodesian government hopes the refinery will be on stream by December 1963 to supply both Rhodesias' requirements of products except for lube oils and aviation gasoline.

Pan American Petroleum Co. is building a multi-million-dollar gas plant in the Windfall field 25 miles northwest of Whitecourt, Alta. Processed gas will be sold to Alberta & Southern Gas Co., Ltd.

Distillers Co., Ltd., and B. F. Goodrich Chemical Co. are planning a major expansion in polyvinyl chloride production. The expansion, to cost $4.6 million, will be at the Barry, South Wales, unit. The facility will be on stream by mid-1961.

Esso Petroleum Co., Ltd., has placed its 100,000-bpd refinery at Milford Haven, Wales, on stream. Construction was handled by Foster Wheeler Corp. (PETROLEUM REFINER, Vol. 39, No. 8, Page 162.)

Mobil Chimica Italiana S.p.A., an Italian chemical company affiliated with Socony Mobil Oil Co., Inc., will build a major plant at Naples, Italy, to manufacture basic chemicals. The plant will produce benzene, ethylbenzene, orthoxylene and paraxylene. Estimated initial total yearly output will amount to 39 million gallons, of which more than 75

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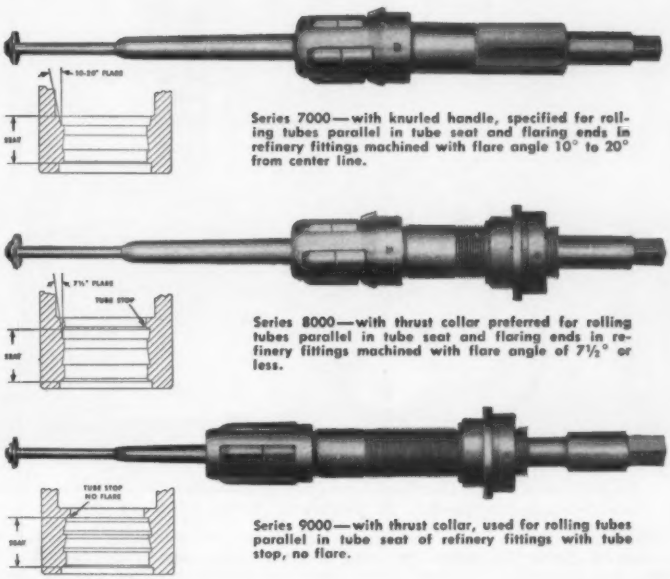
THE QUALITY NAME IN TUBE EXPANDERS . . . SINCE 1892

Tube Expanders for Refinery Installations



Series 7000—with knurled handle, specified for rolling tubes parallel in tube seat and flaring ends in refinery fittings machined with flare angle 10° to 20° from center line.

Series 8000—with thrust collar preferred for rolling tubes parallel in tube seat and flaring ends in refinery fittings machined with flare angle of 7½° or less.

Series 9000—with thrust collar, used for rolling tubes parallel in tube seat of refinery fittings with tube stop, no flare.

#39

IDEAL

Specialization since 1892 in the manufacture of Tube Expanders, Tube Cutters and Operating Accessories provide the right answers to your tube installation and maintenance problems. Write for our new General Catalog 81.

The Gustav WIEDEKE Company

Dayton 1, Ohio

For more data on advertised products, use Readers' Service Cards, last page.

Building . . .

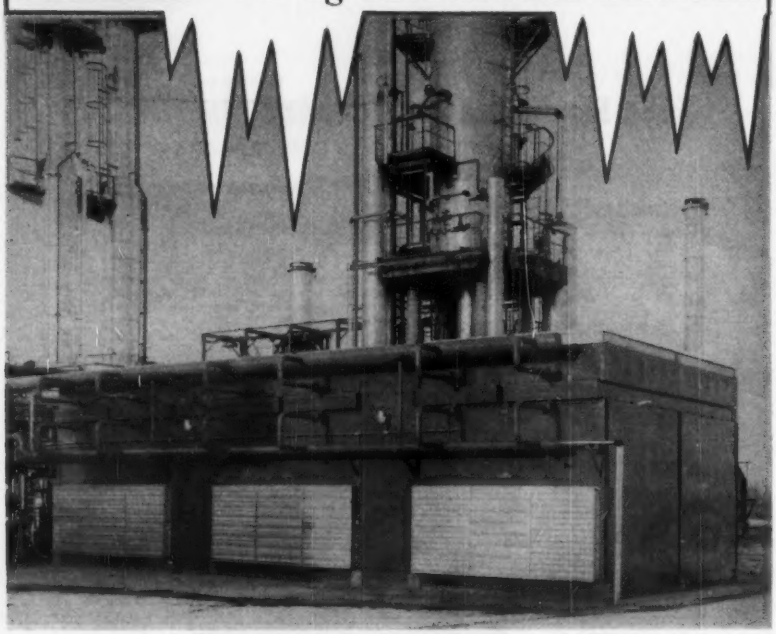
percent will be benzene and orthoxylene. Raw materials will come in large part from the adjacent refinery operated by Mobil Oil Italiana.

Refineria Conchan-California, S.A. has awarded The Fluor Corporation, Ltd., a $1-million contract for the engineering and procurement of a 6,659-bpd crude unit and attendant facilities to be erected at Conchan, Peru. Standard Oil Co. of California is a part owner and engineering agent for the enterprise.

Thailand is planning a $25-million shale oil refinery in the Mae Sod district, Tak province. A Thai-Japanese company has proposed to handle construction of the plant, which is to have a 28,000-bpd capacity. The plans are being studied by the Thai government's Board of Investment.

Haifa Oil Refineries and Delek, a group made up of Sonneborn Chemical Co. and Witco Chemical Co., and a Latin American group, will build three petrochemical plants in Haifa, Israel, to produce ethylene, polyethylene and carbon black. Initial capacity will be 12,000 tons of ethylene, 8,000 tons of polyethylene and about 6,000 tons of carbon black. Completion is expected within two years.

SMITHCO *set-up for warm air recirculation during* SEVERE COLD WEATHER



Large Crude Column Overhead Condenser in Canadian Oil Companies, Limited's new refinery, constructed by Canadian Bechtel, Ltd. in Alberta.

The unit pictured above once again points out the flexibility of design which has enabled SMITHCO coolers to meet and overcome every challenge of extreme weather and operating conditions. It has been customized to offset sub-zero temperatures by recirculating warm air which under normal temperature conditions is discharged vertically at a high velocity. It also features completely automatic control of process temperatures.

The role played by air in the new Alberta refinery is only partially described in this photograph. The entire plant requires only 20 gallons of water per minute **for all services** — dramatic proof of the versatility of air for all types of process cooling and condensing.

All over the world more and more engineers are turning to air as the solution of their heat transfer problems — A SMITHCO AIR COOLED HEAT EXCHANGER MAY BE THE ANSWER TO SAVING COOLING DOLLARS IN YOUR EXISTING PLANT.

SMITHCO
ENGINEERING INC
P O BOX 3217 PHONE GI 7-5545 TULSA, OKLAHOMA

Yawata Chemical Co. has joined Shin Nippon Chisso to form a new company, Kyushu Chemical Co. Chisso owns 70 per cent of the firm, which will produce 100,000 tons per year of ammonium sulfate and 24,000 tons per year of polyvinyl chloride at Chisso's Tobata, Japan, plant. The facility is due to go on stream by April 1962.

Imperial Chemical Industries, Ltd., has been granted approval by the Argentine government to build a 10,000-tons-per-year polyethylene plant. Construction is expected to begin in about six months.

Bitmac, Ltd., has awarded a contract to A.P.V. Co., Ltd., for the design, supply, erection and commissioning of a benzole refinery to process 8 million gallons per year of crude coke oven benzole. In addition to high purity benzene and toluene products, the plant will produce an indene-rich fraction and a 3-degree xylole fraction. No motor benzole will be produced. The refinery will be built at Llanwern, England.

Western Leaseholds, a subsidiary of Canadian Petrofina, Ltd., will build a $6-million gas processing plant in the Wildcat Hills district near Calgary, Alta. Initial capacity of the plant will be 40 MMcfd of raw gas, yielding about 35 MMcfd of pipeline gas along with 450 barrels of stabilized condensate and 50 tons of sulfur. Operations are scheduled to begin in November.

Gelsenberg Benzin has completed a 10,000-barrel platformer at its plant in Gelsenkirchen-Horst, West Germany. Lurgi built the unit, using a UOP process. Lurgi will also begin construction soon on a benzene plant to be used in combination with a gasoline stabilizer and a 7,500-barrel reformer for the firm.

AviSun Corp. and Shin Nippon Chisso Kiryo, K.K., are building a polypropylene plant in Japan with completion set for early 1962. Annual capacity will be 30 million pounds.

Jordan has completed a refinery costing $11.2 million. The money was raised in Jordan and other Arab nations, mainly Kuwait. The plant receives 6,000 bpd of crude oil by pipeline.

India has granted licenses to Duncan Bros. to manufacture polystyrene and synthetic rubber, in collaboration with Phillips Petroleum Co. Other licenses were given PJB Industries to make carbon black, along with Continental Carbon Co.

Dominion Tar and Chemical Co., Ltd., plans to build a 22-million-pound-per-year phthalic anhydride plant adjacent to its present facilities in Toronto. The plant, to cost approximately $3.5 million, will be engineered and constructed by Canadian Badger Co., Ltd., Toronto. Do-

new –

a LINE of 500 psi quality steel swivel joints

APPLY THIS ECONOMICAL

CHIKSAN LFS SERIES SWIVEL JOINT

TO A WIDE RANGE OF LINE FLEXIBILITY NEEDS

Equally effective on lines handling water, hot liquids, fuels or gas, the new Chiksan LFS series joint has many features to commend its use. Sweep radius minimizes flow turbulence. Bearings are factory lubricated—usually sufficient, in normal service, for the life of the joint. In-stream packing is not affected by line surge or vacuum conditions. Fabricated from carbon steel, LFS series swivel joints have a temperature rating of 225°F and up to 400°F with Viton A packing. Available in sizes of 1½″ to 4″ in eight basic configurations. For more facts on this economical Chiksan LFS series joint, please request Bulletin 11-60.

CHIKSAN

fmc

#61-58

CHIKSAN COMPANY—General Offices: Brea, California • Well Equipment Mfg. Corp. Division (Weco Unions, Hamer Valves) • Chiksan International • Chiksan of Canada Ltd. Offices and Representatives in Principal Cities of the World

For more data on advertised products, use Readers' Service Cards, last page.

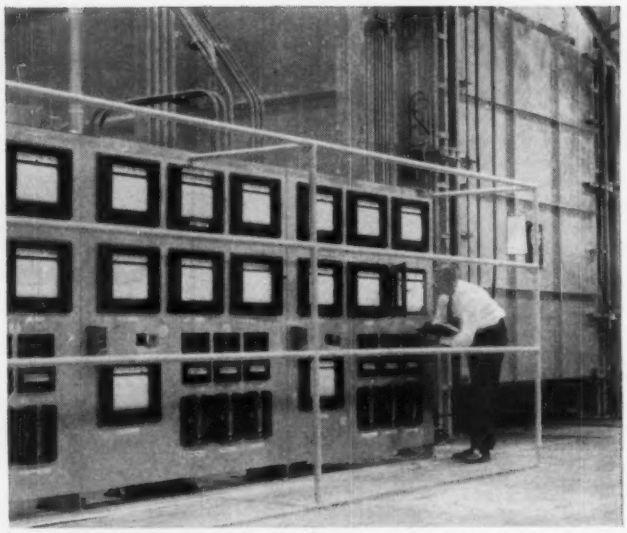
BRISTOL'S INSTRUMENTATION NEWS

News of instrumentation and automatic control in modern industry

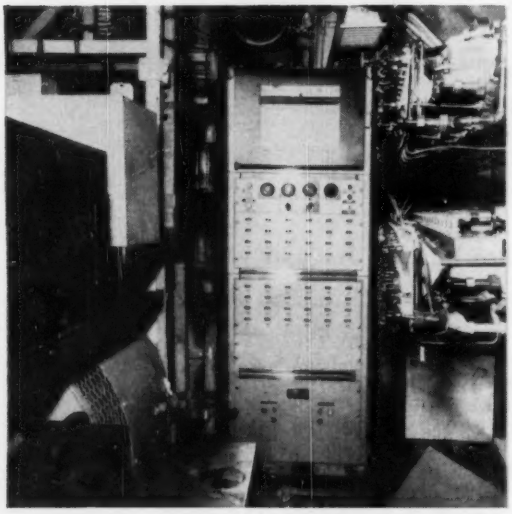
New multi-million dollar plant gets Bristol instrumentation

Bristol Electronic Dynamaster* Potentiometers play a vital part in the control set-up for the new fabricating plant of Anaconda Aluminum Company at Terre Haute, Indiana. They indicate, record, or automatically control temperatures in heat-treating, annealing, aging and soaking operations in a wide variety of furnaces throughout the plant. Other versatile Bristol Electronic Dynamaster instruments measure conveyor speed and function as multiple-zone safety-limit controls.

Comprising 11½ acres under one roof, the new plant turns out aluminum sheets, extrusions, tubes, ingots, and stamped shapes. Permanent records are a big plus in plant operation, says the furnace department foreman. "When a customer has a complaint or praise, we can always check the Bristol records. There's no guess-work involved anywhere."



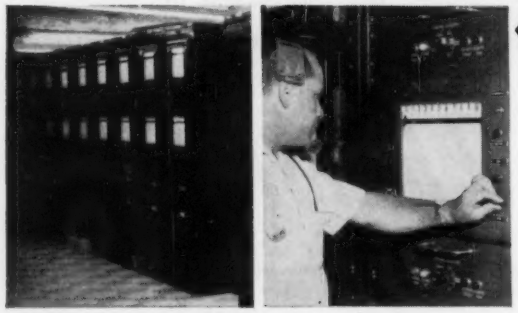
Bristol Electronic Dynamaster* Pyrometers shown here record and control an annealing furnace at Anaconda Aluminum Company's new, multi-million-dollar Terre Haute, Ind., plant. This is one of many panels featuring Bristol Dynamaster instruments in this ultra-modern new plant.



Bristol gets "deep dive diploma" on new Navy subs

The Navy's David Taylor Model Basin is using Gilmore Multichannel Strain Gage Plotters to assist in verifying the strength of new submarine hull designs. Gilmore Plotters, manufactured by Gilmore Industries, Cleveland, Ohio, are built around the basic Bristol Multi-point Dynamaster. Each new submarine design is tested by instrumenting the hull with strain gages and plotting strain vs load (depth). A plot is made at sea level and at 50-ft depth increments. A resultant straight-line plot for all stress points proves the design sound.

The USS ALBACORE was the first submarine tested with results plotted on these units. The ALBACORE embodies new design concepts which have contributed significantly to the spectacular performances of more recent atomic submarines. Most recent was USS SKIPJACK. This use of automatic strain-recording equipment saves manpower and time during the actual dive and in the subsequent analyses of the results.



Dynamaster* recorders monitor countdown variables in Titan missile blockhouse at Cape Canaveral

A large bank of Bristol Dynamaster recording instruments is prominent among the equipment supplied by The Martin Company's Cocoa Division for this blockhouse for the Titan ICBM at the Air Force Missile Test Center, Cape Canaveral. Dynamaster electronic instruments are also in other phases of the Titan ICBM program at Martin's Denver Division. Here they are used in the Propulsion Laboratory to check out kill parameters during tests, and also with the elevated temperature test equipment for aerodynamic flight simulation.

For more data on advertised products, use Readers' Service Cards, last page.

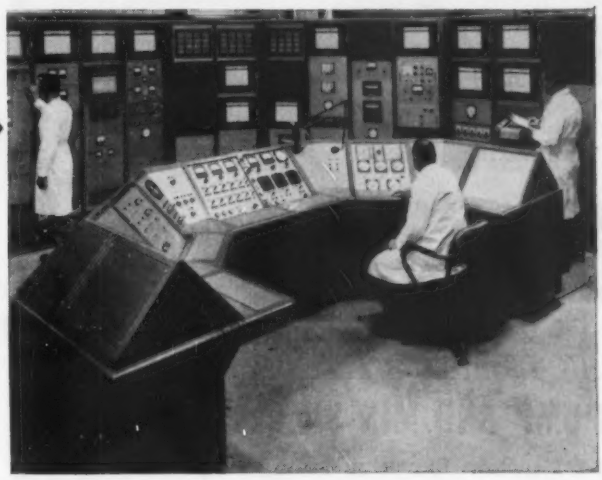
Electronic, nuclear ceramics development at Westinghouse aided by flexible temperature control panel

Bristol Round-Chart Program Controller, Double-Range Controller, Strip-Chart Recorder and Free-Vane Controller are tied into panel patchboard.

This instrument panel was designed by Westinghouse to give utmost versatility in furnace control at the Ceramic Materials Laboratory of Westinghouse Electric Corporation, Pittsburgh, Pa.

Furnaces controlled here are used in development of ceramic materials, such as nuclear fuels, thermistors, ferrites, ceramic resistors and other speciality ceramics. These range from low-temperature (only 1000°F) short cycles to high-temperature (up to 3000°F) cycles involving three soaks over a 72-hour period. Bristol instruments are playing an ever increasing role in modern basic and industrial research. Make sure you have full details before you purchase another instrument for lab use.

Dynamasters record vital data on new Army reactor



World's first mobile self-contained nuclear power plant and first U. S. gas-cooled reactor for generating power—these are the dual aims of the Gas-Cooled Reactor Experiment Program (GCRE-1), being carried out at the National Reactor Testing Station, Idaho, for the U. S. Army and U. S. Atomic Energy Commission by Aerojet-General Nucleonics.

Bristol Dynamaster Potentiometer and bridge instruments have been selected by Aerojet-General, prime contractors and builders of both the reactor and its control stations, to record vital reactor data.

0.5

An Electronic Dynamaster* Potentiometer for every application!

Single-pen, two-pen, and multiple-record (up to 24 points) strip-chart instruments.
One- and two-pen round-chart recorders.
High-speed recorders (0.4 second).
X-Y recorders.
Extended range recorders.
Adjustable span and zero recorders.
Miniature 3-inch strip-chart recorders and indicators.
Electric and pneumatic controllers in both strip- and round-chart models—all types of control action and as time-program control.
Laboratory recorders—unmatched versatility for short-run testing.
Telemetering transmitters.
Drum-type precision indicators.
Multi-bank recorder—will accept up to 200 separate inputs and record them on 12-inch wide strip chart.
Selectomatic multiple point recorder that allows rapid changing of the number of points recorded.
Most models are available in case that fits standard 19" relay-rack without modification to instrument or rack.

TECHNICAL DATA

Extensive technical data on any Bristol instrument is yours for the asking. And, if you have special or unusual problems, our applications engineers will be glad to talk them over with you.

Write: The Bristol Company, 111 Bristol Road, Waterbury 20, Conn.

*T. M. Reg. U. S. Pat. Off.

BRISTOL

for improved production through measurement and control

AUTOMATIC CONTROLLING, RECORDING AND TELEMETERING INSTRUMENTS

For more data on advertised products, use Readers' Service Cards, last page.

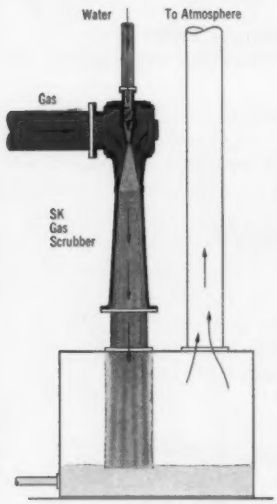
LET SK JET EJECTORS SIMPLIFY YOUR JOB

SK Jet Ejectors are outstandingly simple and reliable. There are no rotating parts to break, none to maintain. Jet ejectors are compact, low in cost. Because of their uncomplicated design, they can be made in many corrosion and erosion resistant materials. Easy to install and requiring little attention, they can be located in remote and inaccessible places. And, most often, they will perform two or more functions at the same time. Pump *and* heat. Entrain *and* scrub. Pump *and* mix. Compress *and* move.

SK Jet Ejectors are worth knowing more about. Ask for Bulletin J-1. It gives brief data on types and functions.

Or circle 250a on Reply Card

SK Ejector-Venturi Scrubbers
SOLVE FUME PROBLEMS



SK Gas Scrubbers operate on the jet principle. Use a pressure liquid, issuing through a spray nozzle, to create a draft, draw gases, vapors, dusts into the unit, scrub them, and discharge clean air.

These scrubbers are (1) *economical*—low in initial and operating cost compared with other types; (2) *efficient*—see data in Bulletin 4R; (3) *readily available*—stocked in popular sizes in Pennsylvania, Texas, California; (4) *adaptable*—made and stocked in cast iron, asbestos-filled resin, PVC, and stoneware to meet service conditions.

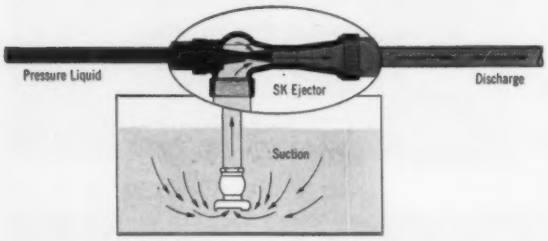
For details—ask for Bulletin 4R

Or circle 250b on Reply Card

SK Liquid Jet Ejectors
PUMP AND MIX SIMULTANEOUSLY

SK Liquid Jet Ejectors utilize the kinetic energy of a liquid under pressure to entrain, mix, and pump liquids or handle slurries and granular solids. Uses vary from pumping out a sump to mixing chemicals in proper proportions.

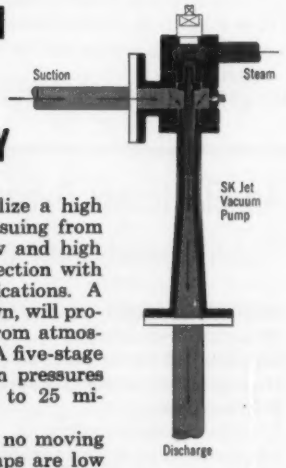
Some user benefits: (1) *economy*—a 2-inch, bronze unit costs only $51.00; (2) *maintenance-free service*—simple construction and lack of moving parts makes supervision unnecessary; (3) *availability*—stocked in popular sizes in Pennsylvania, Texas, California; (4) *adaptability*—made and stocked in cast iron, bronze, stainless steel, asbestos-filled resin, PYREX brand tubing, and PVC.



For details—ask for Bulletin 2M

Or circle 250c on Reply Card

SK Steam Jet Vacuum Pumps
PRODUCE HIGH VACUUM ECONOMICALLY



SK Vacuum Pumps utilize a high velocity jet of steam, issuing from a nozzle, to provide low and high vacuum service in connection with numerous process applications. A single-stage unit, as shown, will provide suction pressures from atmosphere to 1.5 in. Hg abs. A five-stage unit will provide suction pressures from 0.25 mm Hg abs to 25 microns Hg abs.

Simple in design, with no moving parts, SK Vacuum Pumps are low in cost, economical to operate. They are available in popular sizes in various materials from stock in Pennsylvania, Texas, California.

For details—ask for Bulletin 5E

Or circle 250d on Reply Card

JET APPARATUS: Ask for Condensed Bulletin J-1.
ROTAMETERS & FLOW INDICATORS: Ask for Condensed Bulletin M-1.
VALVES: Ask for Condensed Bulletin V-1.
HEAT TRANSFER APPARATUS: Ask for Condensed Bulletin HT-1.
GEAR PUMPS: Ask for Bulletin G-1.

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MANUFACTURING ENGINEERS SINCE 1876
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Building . . .

minion's new plant will use the fluid bed process, which permits lower engineering and operating costs, gives higher yields and produces a higher grade product. Most of the naphthalene to be used as feed will be provided by Dominion Tar and Chemical's own tar distillation plants, including one built in Hamilton in 1957 by Canadian Badger. When the new plant is completed, early in 1962, it will bring Dominion Tar's phthalic anhydride capacity up to 35 million pounds per year.

Lebanon is forming a company to build an ammonia plant near one of its two oil refineries. A group of Lebanese businessmen are seeking foreign know-how and financial participation.

Rumianca, S.p.A. will build a 10,000-metric-tons-per-year polyvinyl chloride resin plant at Pieve Vergonte, Italy, near the Swiss border. The plant, due to go on stream in mid-1962, will cost $3 million.

Imperial Chemical Industries, Ltd., will increase its total alcohols capacity to over 140,000 tons per year by adding a fourth, 30,000-tons-per-year olefin carbonylation unit and by expanding existing butyl and isobutyl alcohol plants.

Chemische Industrie Uithoorn N. V. is building a phthalic anhydride plant at Uithoorn near Amsterdam, Holland. The new plant, which will have an annual capacity of 5,000 tons, will be able to process either naphthalene or orthoxylene to the anhydride. Estimated cost is $1.9 million.

Naphthachimie has put two new units on stream at its petrochemicals plant at Lavera, France. One will manufacture 33,000 tons of ethylene, 35,000 tons of propylene, and 25,000 tons of higher olefins per year. The other unit will make ethylene oxide.

Standard Oil Co. (Indiana) is considering plans to construct a refinery in Queensland, Australia. Ampol Petroleum Co. holds an option on a site in the province for what would be Queensland's first refinery.

Morocco's Samir refinery at Mohammedia is expected to be completed later this year or in early 1962, according to reports from its minister of commerce and industry.

United Carbon Co. plans to construct a $3-million carbon black plant in Venezuela. The plant will be completed late in 1961 and will have an initial rated capacity of 20 million pounds per year. The facility will be operated by

BONNEY WELDOLETS

cut corners safely...

ON ALL 90° BRANCH PIPE CONNECTIONS

Competitive economic times like these make cost cutting mandatory. Reduce piping costs by using Weldolets instead of welding tees for all full size and reducing branch connections. Contractors and owners are saving thousands of dollars on piping jobs by switching to Weldolets. Are you? Write for information.

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also exclusive manufacturers of
WELDOLETS®
THREDOLETS®
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ELBOLETS®
BRAZOLETS®
SWEEPOLETS®
CARBON STEEL
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for all services

BONNEY FORGE AND TOOL WORKS, ALLENTOWN, PA.

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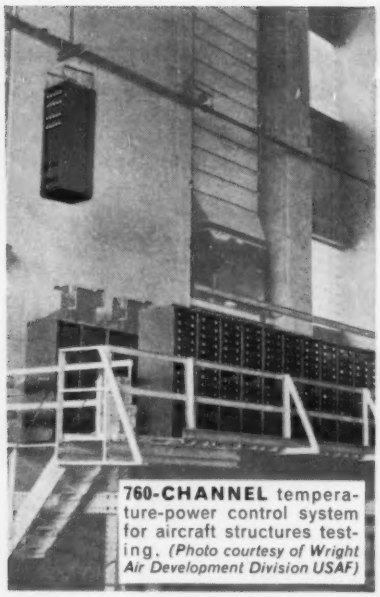
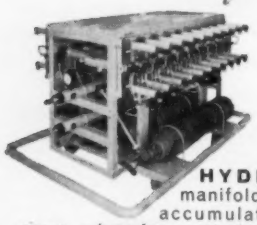


760-CHANNEL temperature-power control system for aircraft structures testing. *(Photo courtesy of Wright Air Development Division USAF)*

Systems Engineering

EXAMPLES are shown here of high response temperature and load control systems we have designed and installed for others. Perhaps the same components and techniques will provide a better solution to your control problem. May we submit a proposal?

REMOTE CONSOLE, makes use of closed-circuit TV observation in multi-channel temperature control system.



HYDRAULIC manifolds, filters, accumulators, and servo valves for a 40-channel rapid loading system used in fatigue testing of aircraft.

CONSTRUCTORS: We are prepared to accept responsibility for design, fabrication, and installation of complex control systems on a subcontract basis.

R-I REPRESENTATIVES are located at *Boston, Atlanta, Dayton, Chicago, Dallas, Denver, Albuquerque, Los Angeles, San Francisco, Seattle, and Toronto.*

R-I RESEARCH INCORPORATED

Box 6164P Minneapolis 24, Minn.

Building . . .

United Carbon de Venezuela, C. A. The plant is slated to be in the Valencia industrial area and the contract for engineering and construction has been awarded to Lummus Co., Houston. Completion of the plant will increase current production of South American carbon black manufacture by 40 percent.

Jefferson Lake Petrochemical Co. and Mobil Oil of Canada, Ltd., are building a gas processing and sulfur recovery plant near Calgary, Alta. The $13-million project is expected to be finished in November. Annual production will be about 285,000 tons of sulfur, 700,000 barrels of condensates and 36.5 billion cubic feet of pipeline gas. Ralph M. Parsons Co., Los Angeles, is handling the construction.

E. I. du Pont de Nemours & Co. and Showa Denko K.K. are forming a new company, Showa Neoprene K.K., to manufacture and sell neoprene synthetic rubber. The company will operate a plant to be built at Kawasaki. Estimated capacity of the facility is 18 million pounds per year.

Hungary is building a crude distillation unit at its Szoney refinery that will increase the plant's capacity by the end of 1961 to 20,000 bpd.

Sardinia has approved a bill that provides for the construction of a refinery by concession holders, together or separately, in Sardinia if crude production exceeds 40,000 bpd.

Polymer Corp. plans to build a plant to make special synthetic rubbers in France and a butyl rubber plant in Britain. Estimated cost of the two projects is $40 million. Part of the capital will come from both Britain and France. On stream date is two or three years off.

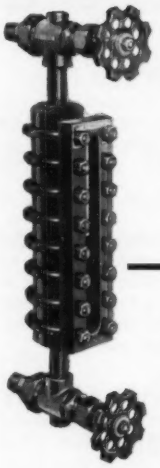
Empresa Nacional del Petroleo has set aside $3 million from its $37-million budget on exploration, development and new facilities in 1961, to build a lube plant in Chile.

British Petroleum Co. and AGIP are building a 4,000-bpd catalytic reformer unit at the Porto Marghera refinery near Venice, Italy. The facility will be completed in mid-1961.

Societe Nationale des Petroles d'Aquitaine will build a 70,000-ton-per-year benzene plant in the Lacq fields, France, to use the hydrodealkylation process. SNPA holds the Lacq field concessions in France.

India plans to build a 20-30,000-bpd refinery at Gujrat. Details or construction commitments have not been made public.

Get the LEVEL READINGS of LIQUIDS THAT BOIL and Flash



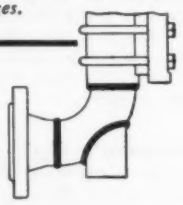
Jerguson Large Chamber Gage

The Jerguson Large Chamber Gage is designed to indicate the level of liquids whose tendency to boil and flash makes an accurate level reading impossible with ordinary gages.

The chamber of this Jerguson Gage is of such large diameter that the level is not badly upset by boiling action of the fluid. This makes possible close level readings, the kind you want and need for accurate control and safety.

You don't have to be satisfied with gages that require guessing at level readings. If liquids boil, install Jerguson Large Chamber Gages and be sure of the liquid level.

The Jerguson Large Chamber Gage is available in reflex and transparent types. Write for full information on this and other Jerguson Gages.



Tapped ¾" pipe threads standard. Available with 2" flanged ends for direct connection to vessel.

JERGUSON

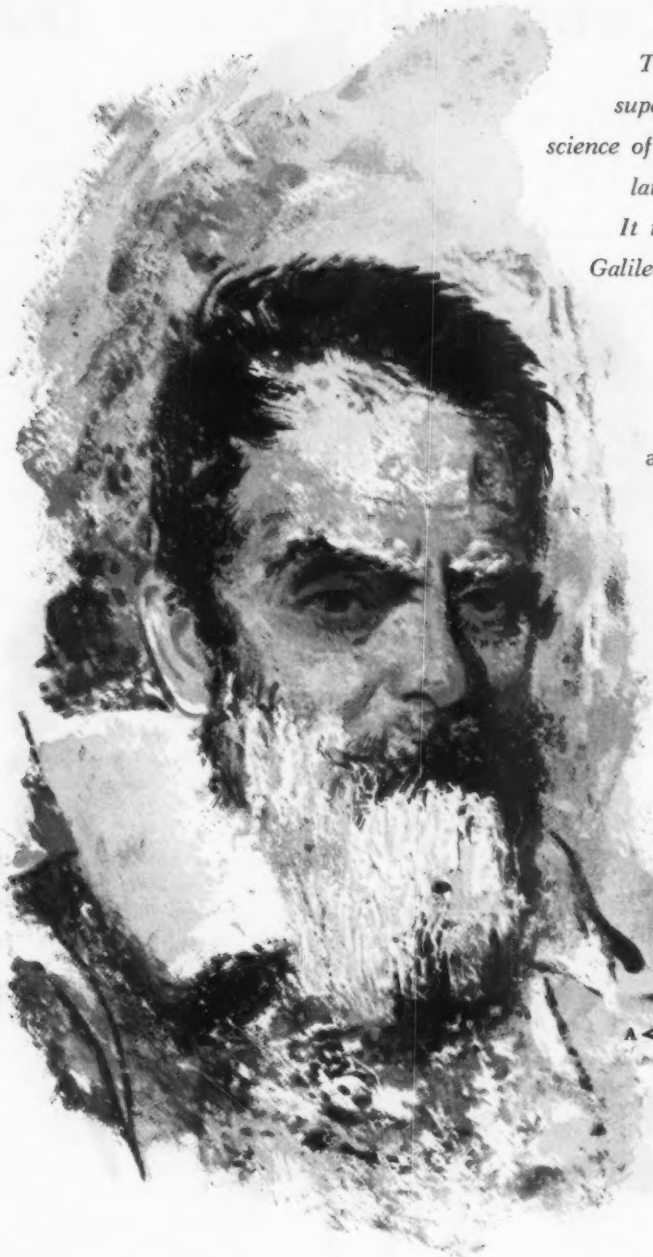
Gages and Valves for the Observation of Liquids and Levels

JERGUSON GAGE & VALVE COMPANY

100 Adams Street, Burlington, Mass.

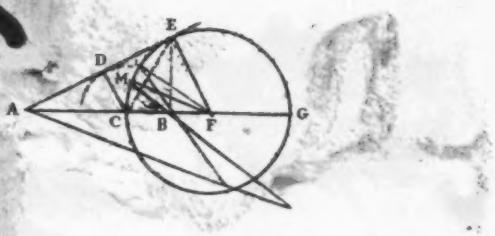
Offices in Major Cities

THE QUALITY OF THINKING



The mind of Galileo—keenly analytical, superbly trained—led him to founding the science of experimental physics, which, centuries later, is revealing the mysteries of space. It is self-evident by his achievements that Galileo's mind reached a level of quality far above ordinary standards of excellence.

Within the same area of meaning, the quality of minds responsible for an engineering project can be evaluated only by results. When you check the record of Brown & Root's engineering through the years, the high quality of thinking reveals itself. Customer satisfaction from greater efficiency at lower costs has built a worldwide reputation for engineering and construction by Brown & Root.



"The knowledge of a single fact through a discovery of its causes prepares the mind to understand and ascertain other facts..."
Galileo

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What's Happening in HPI...

Modest Growth Seen in Plastics in '60

Increased production is forecast for polyethylene, vinyl and polystyrene this year

THE OVER-ALL GROWTH RATE of plastics materials slowed somewhat during the year 1960, according to R. K. Turner, president of Union Carbide Plastics Co., Division of Union Carbide Corp. In some cases the more mature resins showed decreases in sales from their performance in 1959. However, the relatively new resins, high-density polyethylene and polypropylene, showed marked gains.

"A resin such as phenolic, in commerce now for 50 years, has reached maturity," he remarked. "Many of its applications are tied to production of durable goods and capital items, and its fortunes, therefore, are strongly influenced by the economic climate. Any substantial growth in excess of the general economy is unlikely, barring major technological developments, but as a basically important material, any substantial decline is equally unlikely.

"Certain other plastics appear to have saturated their markets and, in some cases, are affected markedly by economic change. While finding useful applications, these materials do not seem destined for appreciable long-term growth.

"In a third category, are the major volume resins, polyethylene, vinyl and polystyrene, which exhibited modest but positive growth during the year.

"This seems to support a fact," Turner said, "that has become increasingly apparent—the fact that the major plastics are becoming firmly established as staple commodities, as articles of commerce. In that role, their future is assured in a constantly increasing number of applications in good times and in bad, but a heavy responsibility is thereby placed on the resin producer. He now manufactures a basic necessity, essential for maximum protection of foods, vital to the field of communications, and of increasing importance in the building and transportation fields as well.

Polyethylene

"As anticipated at the start of the year, industry production of all types of polyethylene increased but at a lesser rate than for previous years. The 1,325 million pounds produced represent an increase of 130 million pounds compared with an increase of 330 million pounds in 1959.

"An increase of 200 million pounds for a total of 1,525 million is projected for 1961. To absorb this production will require a good proportion of the research and development funds mentioned previously for product application.

"Although it has been suggested in some quarters that a plateau has been reached in low-density polyethylene consumption, this scarcely seems likely in view of the number of markets where polyethylene is still in the early stages of use. The field of automatic over-wrapping is an example. Practically non-existent two years ago, this technique is making rapid strides into new market areas and should provide larger outlets for polyethylene for years to come.

"In bread over-wrapping, the adoption of polyethylene film has been somewhat slower than originally anticipated. Resins with excellent processing characteristics have been developed, and there are available new wrapping machines as well as conversion kits for modifying existing equipment to handle polyethylene.

"Another good and far from saturated market is the packaging of fresh produce. A number of food chains are now requesting that their produce be pre-packaged before it reaches the stores. Affording superior protection, increasing sales appeal and providing faster checkouts in this streamlined business, polyethylene film can fill a real need.

"Continued progress has been made in the development of new compounds with improved fabricating or use characteristics for specific applications. One major breakthrough was the development of a crack-resistant polyethylene material to meet the stringent requirements for submarine cable applications.

"The increasingly competitive situation has led to a number of steps to provide even better service to customers. Heavy capital investment has been required to provide storage at suitable locations across the country and to make available special means of transporting bulk resin.

High Density Polyethylene. "After several years of extensive effort directed at the development of high-density polyethylene compounds, major markets have begun to appear for this material. Foremost has been the detergent bottle. Areas in which consumption is still low but future requirements large, include the automotive field where both blow-molded and thermoformed components of high-density material offer great promise.

"Total announced industry capacity for high density now stands at approximately 330 million pounds. With the many problems induced through the variety of different materials needed for specific markets, practical capacity is probably considerably less. Consumption is increasing and now stands at 170 million pounds."

Vinyl

"Vinyl confirmed its position as a billion-pound plastic in 1960 with 1,170 million pounds estimated industry production, proving that its record in 1959 was well-founded. A total of 1,250 million pounds is anticipated in 1961, a figure that can be upped if the outlook for building and construction improves.

"Despite increased usage, an overbuilt situation still exists in the polyvinyl chloride industry — productive capacity being about 35 percent in excess of current sales. Conditions are further aggravated by imports, particularly in film and sheeting. During 1960, some 35 to 40 percent of the domestic rainwear market was held

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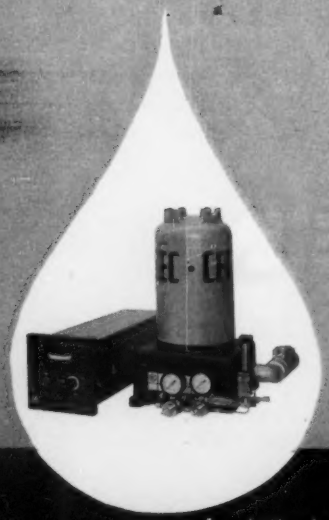
The 26-312 will go anywhere you need it – even in hazardous locations – for continuous measurement of trace water, from 1-1000 ppm, in any liquid of .75 to 1.5 gm/cc density.



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Where would *you* install the 26-312?

For more information, write for Bulletin CEC 26312-X6 or call your nearest CEC sales and service office.

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Happenings . . .

by Japanese imports. As recently as 1958, Japanese imports in this field accounted for only 8 percent of the market.

"On the brighter side, use of vinyls continues to increase in a number of areas. Coatings, both solution and dispersion types, find growing markets. Acceptance by contractors and home buyers of vinyl-coated aluminum siding is growing at a satisfactory pace. Nearly a quarter million homes were covered with coated aluminum siding in 1960. Vinyl in comparison with other coatings is finding increasing use in this application.

"Much of the future growth of vinyl will be attributable to greater penetration of the building field. Already widely used for flooring, luminous ceilings, water stops, and both interior and exterior coatings, vinyls are steadily taking over a greater share of these markets as well as beginning to find use in other functional elements of buildings."

Polystyrene

"Modest improvement was noted for polystyrene in 1960—up 53 million pounds from the 977 million pounds estimated industry production in 1959. With 1,030 million pounds estimated for 1960, styrene joins polyethylene and vinyl as a billion-pound-per-year resin. A total of 1,120 million pounds is projected for 1961.

"Major price reductions made in the Fall of 1959 were followed by similar decreases recently. In the meantime, considerable expansion in both monomer and polymer production facilities has taken place.

"**Among the important** product developments of the year, was a new extra-high impact material produced both in regular and self-extinguishing forms. Maintaining very high strength over a wide temperature range, and with low-moisture absorption and good resistance to distortion, the new material is rapidly carving out markets in the appliance and other fields. Housings made of this material for appliances, room air conditioners and motors are durable, warp-free, and offer increased safety because of the fire-resistant characteristics.

"Another development was a new medium-impact material displaying unique properties when molded in thin sections. Because of the extremely low orientation developed during molding, the material has great strength even at sub-freezing temperatures. Extensive use in the frozen food field is expected.

While blow-molding is largely a polyethylene technique, it holds promise for all the thermoplastics. Polystyrene, for example, offers economy in blow-molded applications where its properties are adequate. One pound of polystyrene provides rigidity equal to that given by 1.4 pounds of polyethylene, and cost per pound is lower."

Phenolic

"Decreased production of capital goods has had an inevitable effect on phenolic

consumption; and phenolic industry production, estimated at 570 million pounds for 1960, was down 55 million pounds from 1959. Unless an early up-turn in the general economy takes place, a slight further decrease to 560 million pounds may be expected in 1961.

"Despite the poor short-term prospects for phenolic, we have complete confidence that it will long remain the resin 'too good to be outmoded'.

"**A breakthrough in** the development of phenolics with greater heat resistance was one of the major accomplishments of the year. These new materials withstand four times longer exposure at 500° F than the best previously available phenolics. Important applications are foreseen in the appliance, automotive, missile and other fields where high-temperature durability is required.

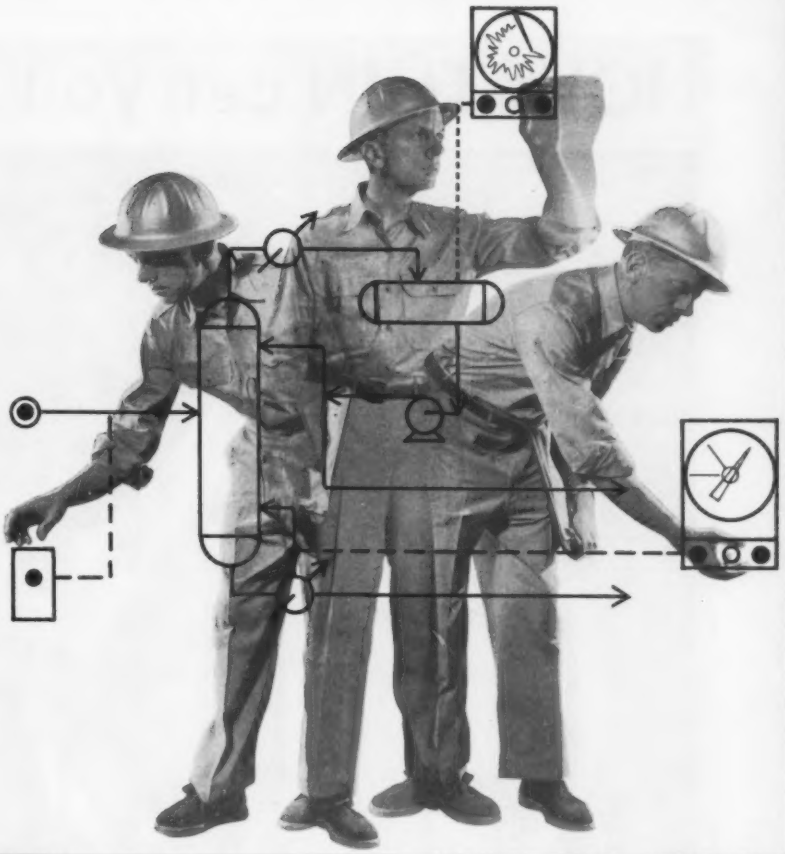
"Phenolics have in the past found use in the production of wood panels—plywood, chipboard, wood waste composition board, etc., but their growth has been limited by their relatively high price compared with that of urea bonding materials. The increasingly apparent need for better properties, particularly water-resistance, has drawn serious attention to the broader application of phenolics in this area. Pre-fabricated panel construction, a fast-growing technique urgently needed to maintain reasonable costs in domestic housing, requires bonding materials with high strength and moisture-resistance. Phenolics provide a thoroughly satisfactory solution to this problem."

Epoxy

"With industry production in 1960 at 60 million pounds, up from 57 million in 1959, the epoxies continue to show modest growth. While few major new uses have appeared during the year for this relatively young member of the plastics family, it is becoming solidly entrenched in a variety of fields because of properties offered by no other material.

"**The inherently high cost** of epoxy compared with most other resins has been somewhat of a hurdle. As factors of quality and service life receive more attention, however, it appears that long-range economies can be achieved with this resin in large-scale applications where cost must be a matter for careful consideration.

"One such instance is the surfacing and repair of highways. Viewed with caution by highway authorities when first proposed because of materials cost, the demonstrated performance of epoxies in test sections of highways surfaced several years ago has led to a change of opinion. The widespread use of epoxy surfaces on bridges, ramps, and other important highway components appears possible in the near future. Any strong move in this direction during this year could very favorably affect the 65-million-pound production forecast for 1961."



Control problems on your hands?

CEC's Chromatographic closed-loop control instrumentation is available for virtually every plant and process

Now you can replace manual set-point control with a chromatographic closed-loop control package that matches the pneumatic, electronic or computer control system in your plant. These control packages, built around the 26-212 High-Speed Process Chromatograph, can be constructed from off-the-shelf modules for every type of control... or custom engineered for special applications. CEC's foremost engineering background in chromatographic control guarantees a package compatible with your system.

The 26-212 Process Chromatograph makes it possible. **High speed and flexible design are keys to the 26-212's excellence for process control. Accurate analyses are produced in 1/20th to 1/50th the time of other instruments. This permits precise control of rapidly changing processes. An integral electronics patchboard facilitates tailoring of the instrument to specific applications – actually permits instrument modifications and system redesign by plant personnel. In addition, the 26-212 provides continuous, maintenance-free operation.** ***For a complete description of the 26-212's features and CEC's closed-loop control capabilities, write for Bulletin CEC 1860-X10 or call your nearest CEC sales and service office.***

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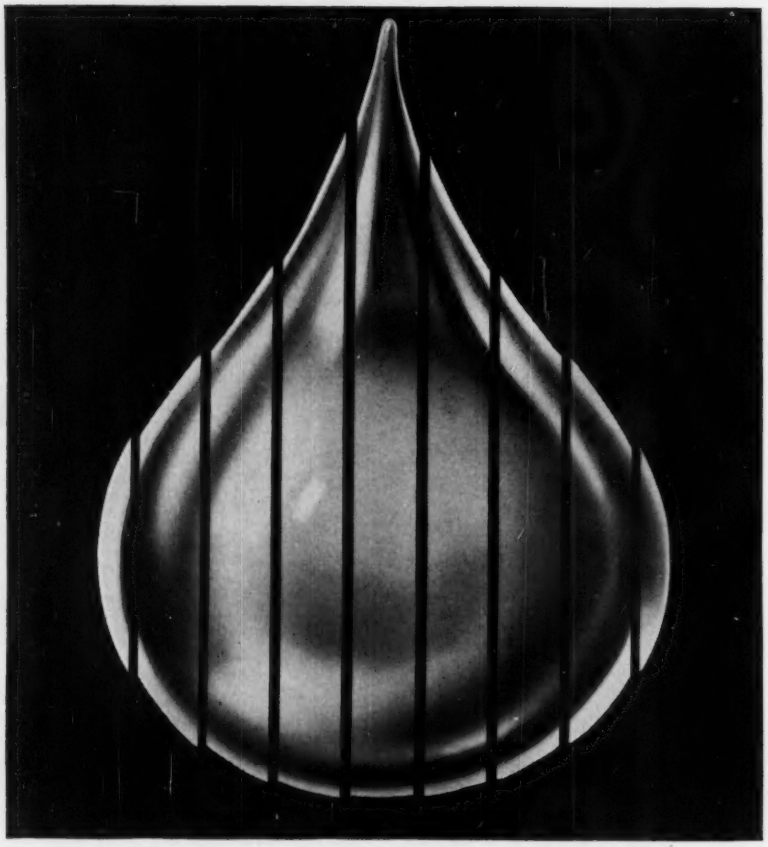

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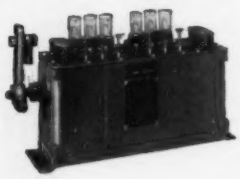

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Happenings . . .

Demand Drop Expected To Cut Refinery Runs

A sharp seasonal drop of 1 million bpd in U.S. oil demands over the next three months will reduce the market for domestic crude oil and bring on a need to curtail refinery operations, the Independent Petroleum Association of America reports.

In its February "Supply and Demand Outlook," IPAA said the market for crude oil in the March-May period would average 7 million bpd, 200,000 barrels below February output and 220,000 bpd less than actual production in the same months last year.

Pointing out that crude runs to refineries averaged 8,125,000 bpd in the past three months and 8,400,000 barrels in January, the association said, "Average runs of about 7,900,000 bpd for the March-May period appear adequate."

Weather in the November-January period was 11.5 percent colder than the same months last year, bringing total petroleum demand to an average of 10,925,000 bpd in this period, up 3.2 percent from November-January 1960, IPAA said.

In the next three months, however, in anticipation of "normal" temperatures, the association foresees total petroleum demand of 9,600,000 bpd, 200,000 barrels daily or 2 percent less than in the same months last year when March was 30 percent colder than normal.

Petroleum inventories at the end of January totaled 759 million barrels, only 32 million barrels below "burdensome level" of January 1960, said IPAA, and inventories of all fuel oils were in ample supply, "despite abnormally cold December and January."

In connection with refinery operations in the next three months, IPAA said, "continuation of relatively high yield of distillate fuel oil during the next few weeks will serve a dual purpose of meeting anticipated heating oil demand while avoiding large additions to already high gasoline inventories."

Based on the seasonal demand outlook and required refinery runs in the next three months, IPAA said total new petroleum supply required in this period will average about 9,775,000 bpd.

This new supply would consist of total imports of crude oil and refined products of about 1,800,000 bpd, natural gas liquids production estimated at 975,000 bpd, and 7 million bpd of domestic crude oil.

Chemical Plant Can Be Designed by Computer

A Shell Development Co. research team of engineers and mathematicians has devised a system of logic by which an electronic computer is used to design the most efficient plant needed to produce any type of chemical.

In a final test of the system, the com-

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PETROLEUM PROCESSES PLANNED FOR YOUR PROFIT

The wide range of HOUDRY processes offers a selection of routes to maximum yields and highest product quality from many different grades of petroleum raw materials.

Two examples: the HOUDRIFLOW catalytic cracking process converts any fraction between naphtha and asphalt—from either sweet or sour crudes, liquid or vapor feed—to high octane gasoline; HOUDRIFORMING produces extremely high yields of high octane gasoline, blending stocks, and aromatics from straight-run and cracked petroleum naphthas. HOUDRY processes also include DEHYDROGENATION and DESULFURIZATION. Over the full range of catalytic processing, HOUDRY supplies not only basic experience in process design, but commercially-proved services as well—in catalysts, research, engineering...and economic consultation.

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DALPAC® 4 SAVES YOU MORE

Refinery customers have found that, in comparison with other inhibitors, Dalpac 4 (Hercules 2,6-di-tert-butyl-p-cresol) saves up to three dollars on every thousand barrels of gasoline produced. Dalpac 4 inhibits gum formation, stabilizes gasoline color, and helps maintain engine cleanliness. Refiners have also found it to be excellent in turbine and transformer oils where it prevents deterioration, and does not affect electrical properties.

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Happenings . . .

Partners In Safety Dr. A. P. Beutel (left), vice president of The Dow Chemical Co's Gulf Coast operations, and Ralph J. Farmer (right), project manager, Tellepsen Petro-Chem Contractors, share a look at their recently earned award for 2 million manhours of accident-free operation.

puter designed a chemical plant that would cost from $250,000 to $600,000 less to build than the best previous design of the group of engineers. This savings represents from 5 to 6 percent of total construction costs.

The plant is designed to produce ethylene oxide, used in making anti-freeze. The computer's design also reduced the cost of producing the chemical by 5 to 10 percent. The initial parts of the new computer program were tested on a process to produce polyisoprene and on the design of plants used to produce gasoline. Similar savings were found for these processes.

Crude Figure Shows Increase for November

Production of crude petroleum in the United States averaged 7,133,000 bpd in November, an increase of 175,000 bpd over the October average of 6,958,000 bpd, reports the Bureau of Mines, United States Department of the Interior. Compared with October, most major producing states recorded increases in production during the month. November daily average crude production in Texas, Utah, and Louisiana was up from the October levels by 97,000, 30,000, and 22,000 bpd, respectively.

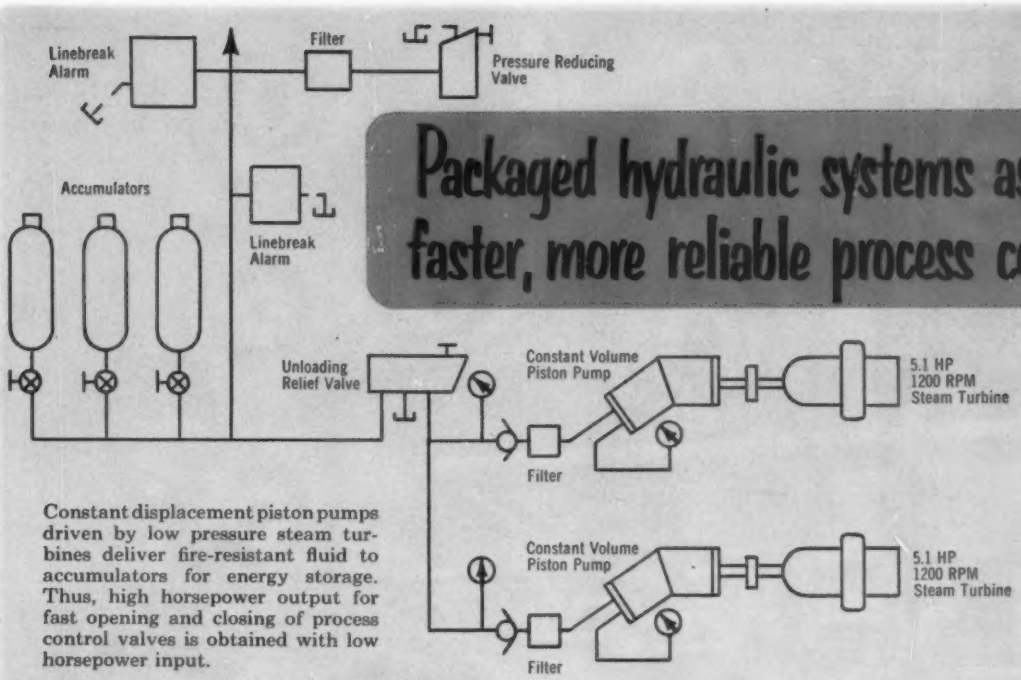
The indicated demand for all crude oil in November decreased 25,000 bpd, comprising an increase of 84,000 bpd for domestic crude and a decrease of 109,000 bpd for foreign crude. Total crude stocks, domestic and foreign, amounted to 239,528,000 barrels on November 30, compared with 232,990,000 at the end of October, an increase of 6,538,000 barrels.

Total crude runs to stills in November averaged 7,893,000 bpd, compared with 7,908,000 bpd in October. During the month runs of domestic crude increased 91,000 bpd and runs of foreign crude decreased 106,000 bpd.

Stocks of refined products at the end of November amounted to 553,234,000 barrels, a decrease of 9,087,000 barrels during the month but 810,000 barrels above the level of stocks reported for November 30, 1959.

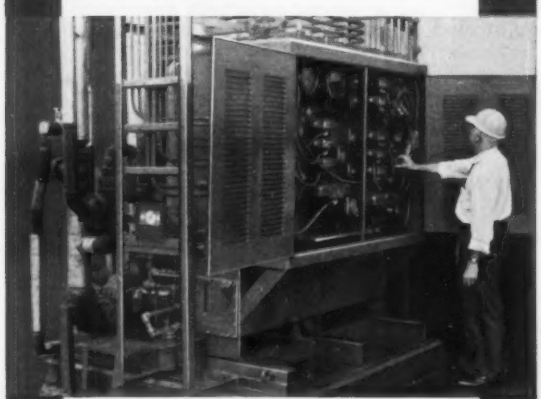
Total demand for all oils in November

Packaged hydraulic systems assure faster, more reliable process control



Constant displacement piston pumps driven by low pressure steam turbines deliver fire-resistant fluid to accumulators for energy storage. Thus, high horsepower output for fast opening and closing of process control valves is obtained with low horsepower input.

Control console and power unit form electro-hydraulic system for controlling automatic heat treatment cycle. Physical layout provides optimum circuit efficiency, ease of servicing, and good appearance.



This power package includes all hydraulic pumps and valves for complete control of automatic cyclic operation of process in a butadiene plant.

Fast and precisely controlled motions, having the high reliability demanded by modern processing, are inherent characteristics of hydraulics. In addition, these advantages are obtained at low cost, for you can cover your full range of operations—from valve control to power transmission—with standard Vickers components. Your engineers enjoy unlimited design flexibility through a choice of electric, electronic, pneumatic and manual signals to control the hydraulic pumps, motors, cylinders, and variable speed drives.

Vickers complete packaged systems are ready to go into service upon arrival in your plant, since they are thoroughly pretested before shipment. They are properly designed and built to give maximum service life with little downtime, thus helping to keep your plant on stream.

Get more information on the job being done by Vickers packaged hydraulic systems in chemical, petrochemical, petroleum refining, and other processing industries by writing today for Bulletin I5802, "Packaged Hydraulic Systems for Process Control."

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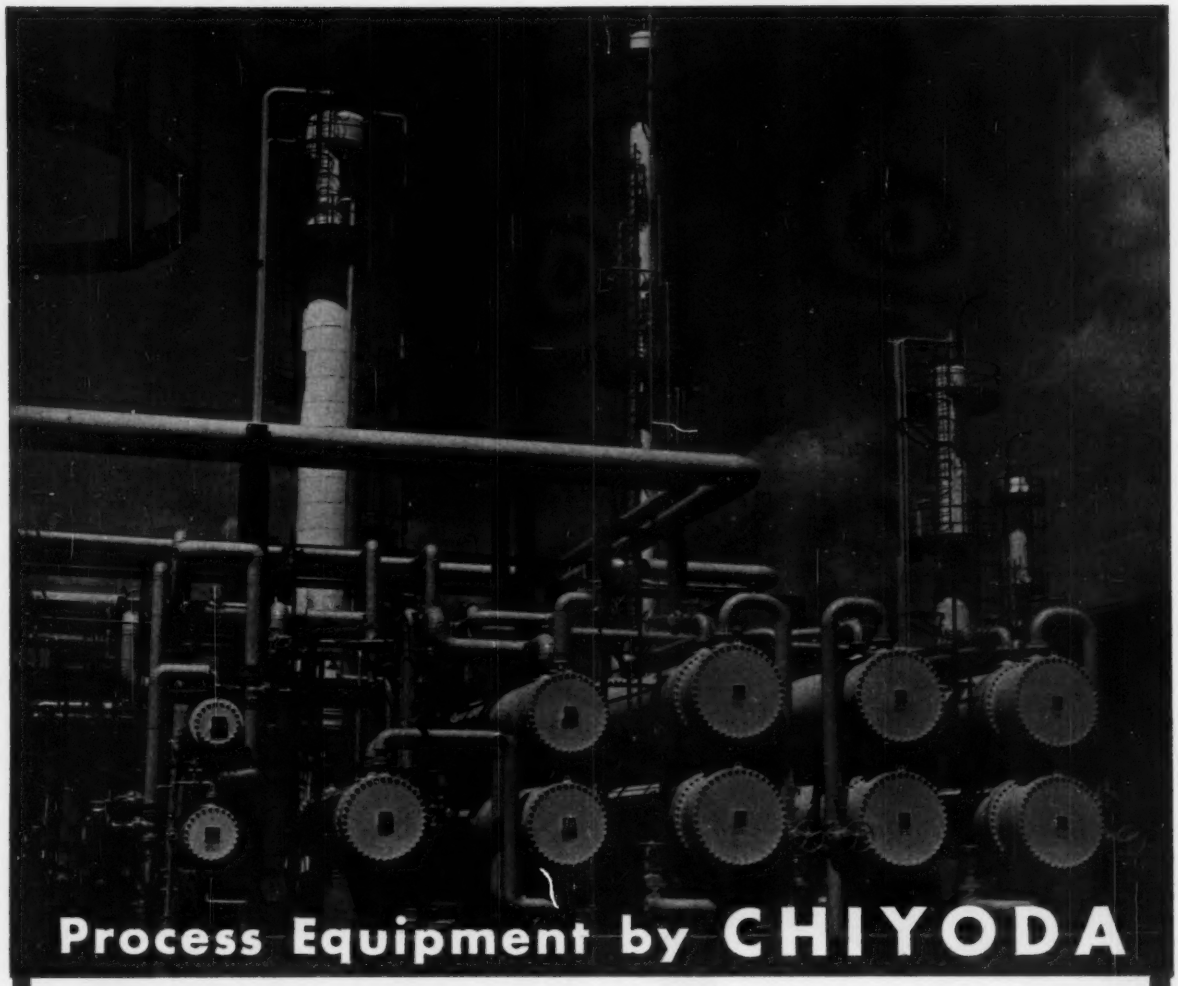

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Heat exchangers, towers, vessels, tanks and other process equipment, large or small, single or by the scores, standard or special, are fabricated at Chiyoda's Kawasaki Factory with the most modern fabricating and testing equipment.
With an integrated organization staffed by specialists in every field plus lower man-hour costs, Chiyoda assures clients of early delivery, low maintenance cost, high operating efficiency and long life.
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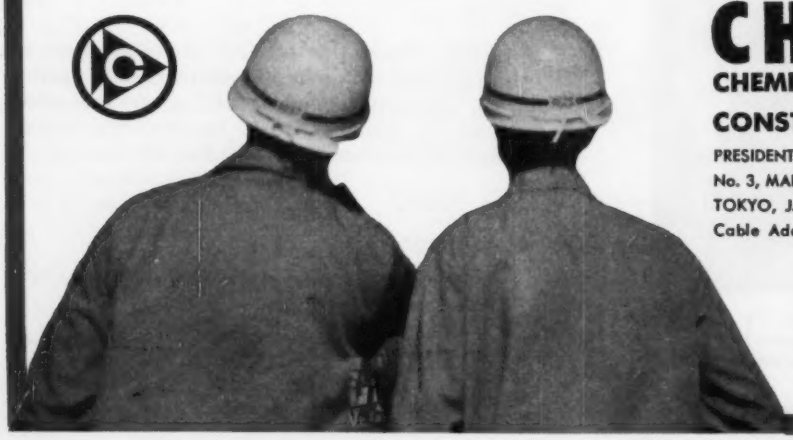


was 10,161,000 bpd, including domestic demand amounting to 9,989,000 bpd and exports of 172,000 bpd. Compared with November 1959, this represented increases of 1.2 percent in total demand and 1.0 percent in domestic demand.

The total crude oil capacity of operating refineries in November was 9,701,000 bpd, indicating an operating ratio of 81.4 percent, compared with 83.5 percent in October.

Crude Consumption At 7 Million bpd for March

Domestic crude consumption or exportation is estimated at 7,010,000 bpd for March by the Bureau of Mines, U.S. Department of the Interior. February's forecast was 7,250,000 bpd.

Total gasoline demand for March is estimated at 40,005,000 bpd, gasoline yield of 44.7 percent, and total crude runs of 7,950,000 bpd. December data showed total crude runs of 8,010,000 bpd, including foreign runs of 968,000 bpd.

Crude runs to stills for January were 8,319,000 bpd, including foreign runs of 1,041,000 bpd. Indicated demand for domestic crude in January was 7,327,000 bpd, with production of 7,177,000 bpd.

Stocks of distillate were reduced 31.5 million barrels during January, and residual stocks were down 2.1 million barrels. Gasoline stocks reached a new high for the month, increasing 16.2 million barrels to 212.5 million barrels.

New Celanese Plastic To Replace Metals

A new high-strength plastic that promises to replace millions of pounds of metals and other plastics has been developed by Celanese Corp. of America.

The plastic is made by a new chemical process and is classified chemically as an acetal co-polymer. Production has begun at Celanese facilities at Clarkwood, Texas.

Field tests also have proved that the plastic can carry heavy loads over long periods of time at high temperatures. Resistance to attack by a wide range of chemicals, including alkalis, is another outstanding advantage for the material.

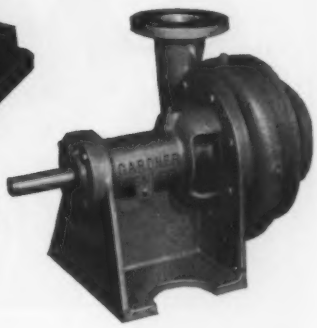
The largest immediate use for the plastic is expected to be in replacement of metals, such as die-cast zinc and aluminum, brass, copper and steel.

UOP Submits Anti-smog Device for Testing

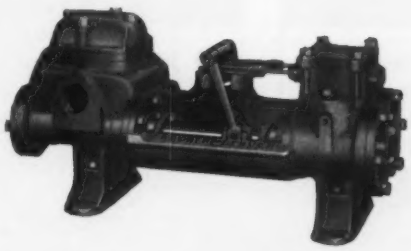
The first formal application for California state testing of an automotive anti-smog device has been made by Universal Oil Products Co., Des Plaines, Ill. The company has made formal application to the California State Motor Vehicle Pol-

Quality pumps with rugged reserve for refinery service

Gardner-Denver BH—four sizes. Provide range from 55 to 550 gpm. Designed for high-speed, high-head operation.

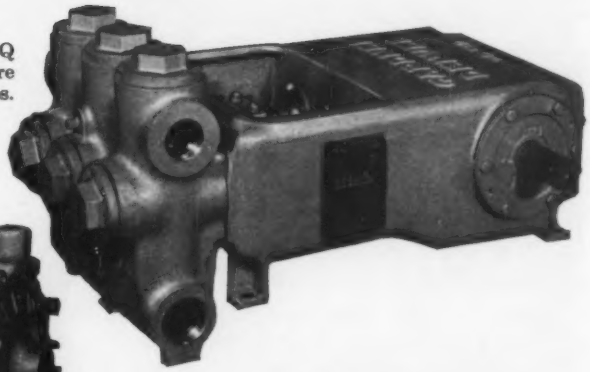


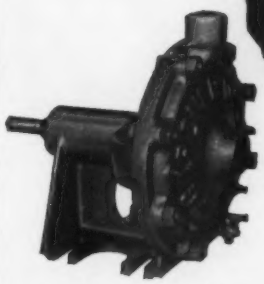
Gardner-Denver BL—five sizes. Provide range from 100 to 1600 gpm. Highly efficient in taking variations in head or volume.



Gardner-Denver duplex reciprocating pumps for operation on steam, air or gas. Eight sizes produce from 9 to 294 gpm.

Gardner-Denver PQ and PS high-pressure triplex plunger pumps. PQ size, 2½x2 . . . PS size, 2¾x2½.





Gardner-Denver CAY 1″ reversible circulating pump operates efficiently in either direction. Handles up to 65 gpm.

All Gardner-Denver pumps are engineered with rugged reserve for trouble-free operation and long-lasting duty. Your Gardner-Denver pump specialist can help select the best pump for your requirement. Call him soon, or write for information.

EQUIPMENT TODAY FOR THE CHALLENGE OF TOMORROW

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Gardner-Denver Company, Quincy, Illinois

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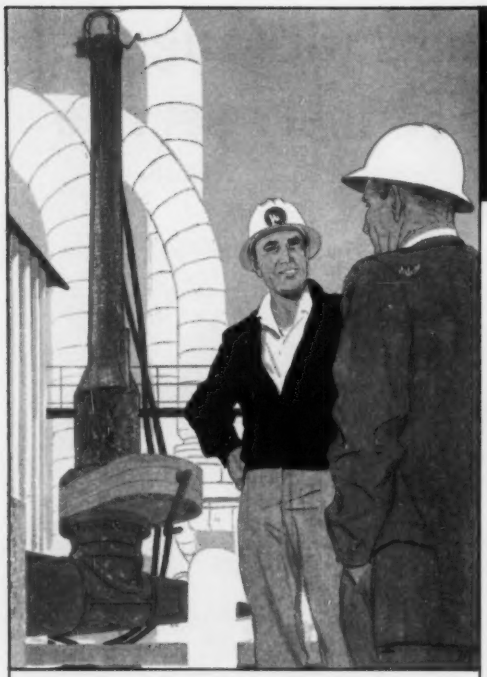
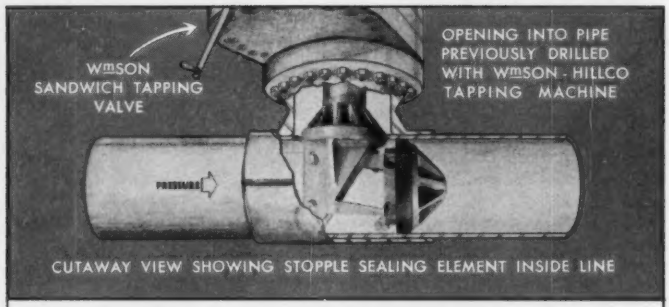


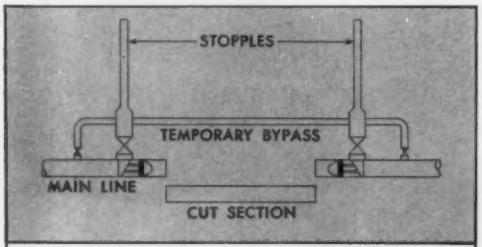
NEWS FROM DOWN THE LINE!

Another plant avoids costly shutdown with WmSON STOPPLE® Plugging Machines

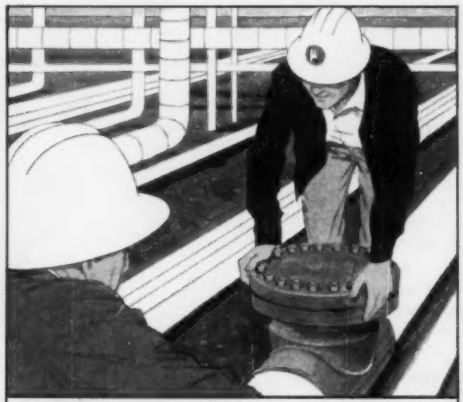


❶ "The STOPPLE is holding pressure in this line while a gas separator is being installed. The flow is diverted through a bypass eliminating shutdown. STOPPLES serve as temporary block valves installed anywhere in a piping system."

❷ "Here's how the STOPPLE works. After the tap is made, the STOPPLE is mounted on the WmSON SANDWICH® Tapping Valve, and the sealing element is lowered into the line, stopping the flow completely."

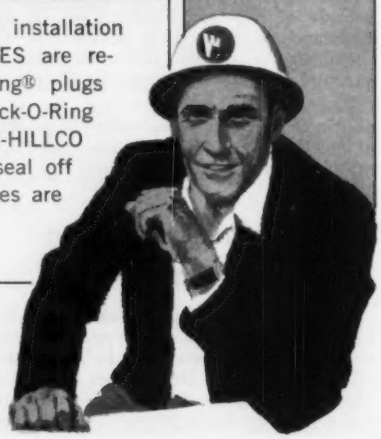


❸ "We're using a pair of STOPPLES on this job, one upstream and one downstream. Had there been an existing valve in the right place, only one STOPPLE would have been required."



❹ "When the separator installation is complete, STOPPLES are removed and Lock-O-Ring® plugs are lowered into Lock-O-Ring flanges by the WmSON-HILLCO Tapping Machine to seal off the tap. Tapping valves are recovered for re-use."

WmSON STOPPLES can be used safely in most plant and refinery applications—available for rental or purchase



For further information consult your WmSON Representative or write factory.

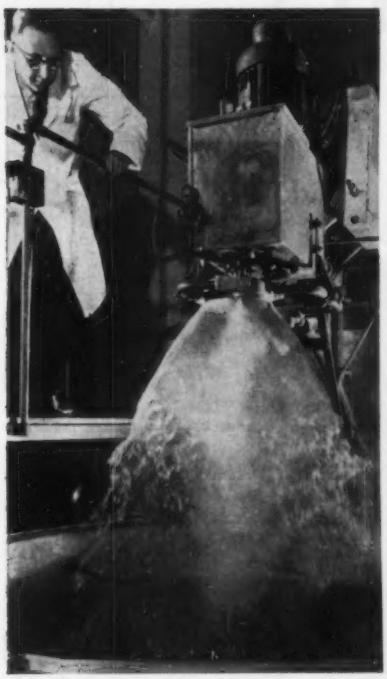
Write Dept. G for Bulletin A-511A

T. D. Williamson, Inc.
P. O. BOX 40 TULSA 2, OKLAHOMA
REPRESENTATIVES AROUND THE WORLD

lution Control Board for the testing program which is expected to result in certification of at least two auto exhaust devices later this year.

It was the first application to be received by the board with indication of test data in accordance with instructions contained in the application form, according to Donald A. Jensen, executive officer of the board.

The muffler is a control device that converts objectionable hydrocarbons and other exhaust products through catalytic action.



A wax spray rig used in determining the size distribution of particles produced by fuel oil atomizers is being operated by a Shell International Petroleum Co., Ltd. scientist at a new combustion laboratory in Egham, England. Information gleaned at the new laboratory, one of the world's largest, will be made available to Shell Oil Co. and will supplement the heating oil and diesel fuel research program conducted at Shell's Wood River, Ill., research laboratory.

Natural Gas Liquids Has 7 percent Rise Over '59

Production of natural gas liquids in November was 7 percent above November 1959, according to the Bureau of Mines, U.S. Department of the Interior. The daily average production of liquefied gases at refineries was 7.5 million gallons, 10 percent above November 1959.

Ethane-ethylene production in Novem-

chemical processors!

no capital investment for an over-the-fence oxygen plant built with

LINDE / CERTAINTY

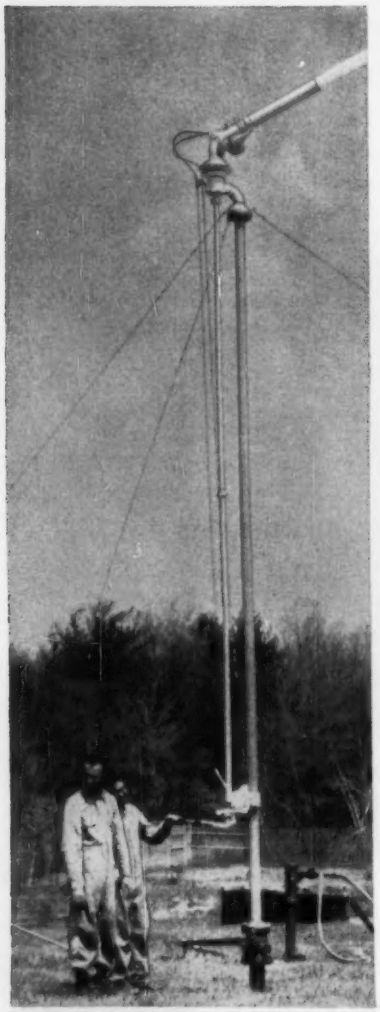
CERTAINTY that your final cost of oxygen will not be upped from the original estimate. CERTAINTY that your cost over the contract period will be as low as possible, in keeping with requirements for purity and trouble-free operation . . . the result of LINDE's advanced engineering features.

LINDE COMPANY
DIVISION OF UNION CARBIDE CORPORATION

UNION CARBIDE

Fight fires from any angle...
WITH ROCKWOOD SPECIALTY TURRET NOZZLES

Getting The Upper Hand...



Rockwood Extended Manual Control Turrets can be located 10 to 20 feet above a remote control station on the ground. Greater discharge range increases their fire fighting coverage. Higher extensions are engineered for special applications.

On the ground, on trucks, or towering over the flames, Rockwood Turret Nozzles are valuable fire fighting aids for use in refineries and chemical plants.

In fact, Rockwood makes the most complete line of specialty turret nozzles on the market. Every type is designed to fight fire four ways: with solid FOAM stream, FogFOAM, WaterFOG or solid water stream. And all are easily adjustable to meet changing fire conditions.

Throughout the country these Rockwood advancements are proving they can hit fires harder and faster. Find out how well they can protect your own plant. For an illustrated booklet on this complete line, write to Rockwood Sprinkler Company, Portable Fire Protection Department, 509 Harlow St., Worcester 5, Mass.

BLISS ROCKWOOD

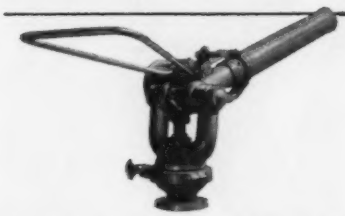
ROCKWOOD SPRINKLER COMPANY

A Division of The Gamewell Company
A Subsidiary of E. W. Bliss Company

Engineers Water ...to cut fire losses

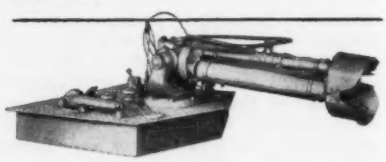
Distributors in all principal cities

Fighting Fires Four Ways

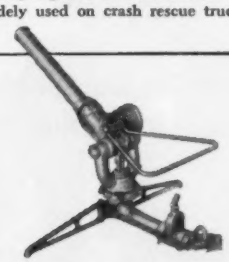


Rockwood Direct Manual Control Turrets give fire fighters "on deck" control from their cab roofs.

A Remote Manual Control Turret is easily handled by a man in the driver's seat. Ideal for fast action.



The Remote Hydraulic Control Type, single or dual model, is power controlled from within the cab. Widely used on crash rescue trucks.



The Portable Type goes off the truck and into action in seconds – wherever hose lines can be brought into action.

ber was 17 percent above November 1959. Demand for liquefied gases for fuel and chemical uses decreased 4 percent from November 1959.

Stocks of liquefied gases, excluding ethane, totaled 1,263 million gallons, a decrease of 85 million gallons during November 1960. Underground stocks of liquefied gases totaled 911 million gallons, 36 million gallons above a year ago.

The daily average demand for natural gasoline was 11 million gallons, an increase of 1 percent over November 1959.

WPRA to Aid Graduate Engineering Students

The first fellowship to be offered to graduate engineering students interested in highway engineering, and particularly asphalt technology, has been awarded by Western Petroleum Refiners' Association.

Arrangements were completed with the University of Michigan so that study under the $2,500 fellowship will begin with the fall semester.

In addition to the contribution by WPRA, the cost of the fellowship is being shared by The Aurora Gasoline Co., Detroit; Leonard Refineries, Inc., Alma, Mich., and The Ohio Oil Co., Findlay, Ohio.

Instrument Research Lab Set Up by Dow Chemical

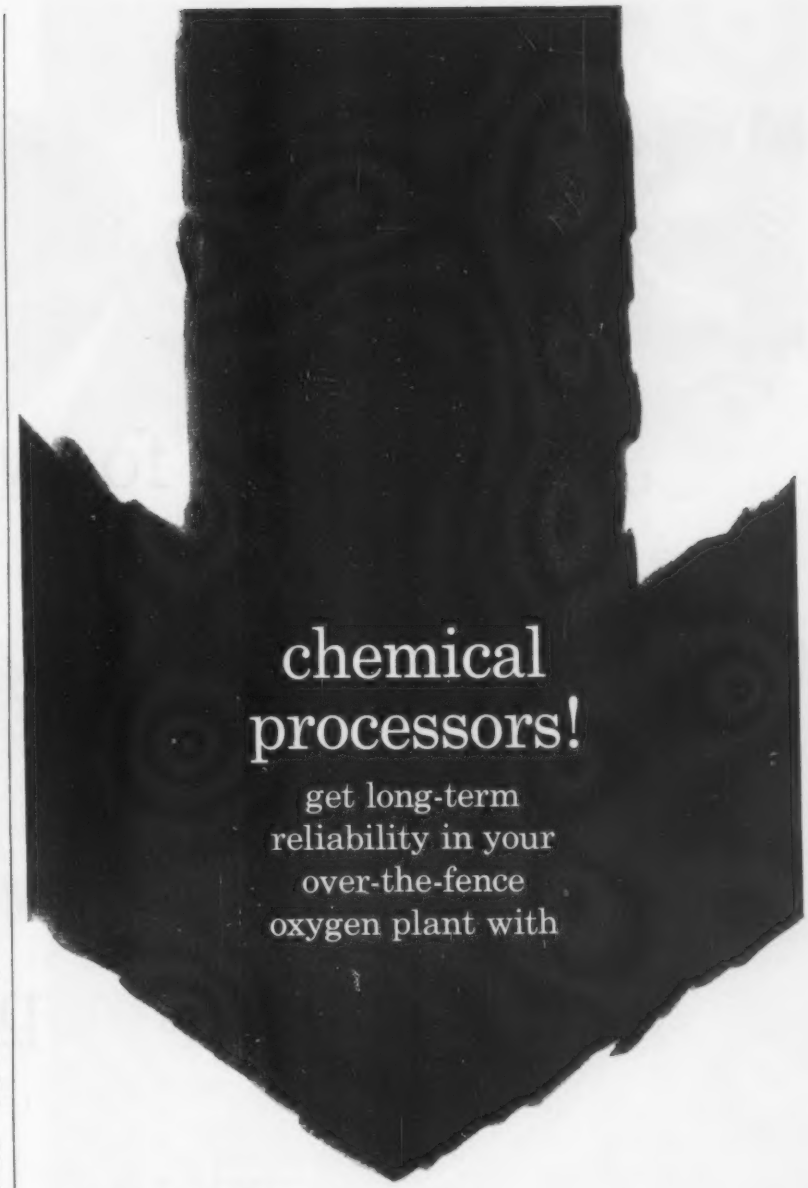
A new laboratory has been set up by The Dow Chemical Co. known as the Instrument Systems Research Laboratory. Located at Midland, Mich., the laboratory will assist all Dow personnel including research, engineering and production groups with problems relating to instruments and instrument applications.

Major emphasis will be on process instrumentation involving all types of stream analyzers, computers and specially-designed equipment as well as the more conventional commercially available equipment.

Petroleum, Products in New Export Gains to Japan

Massive expansion in economic activity in Japan caused a substantial increase in United States exports of petroleum and products, totaling $11 million in the first six months of 1960. Shipments to Japan totaled $40.9 million, compared to $29.9 million during the comparable period in 1959.

A current study of U.S. trade with Japan, just published by the U.S.-Japan Trade Council, comparing the first half of 1960 with the same period of 1959, shows that U.S. exports to Japan in this period were $646 million with imports



LINDE / CERTAINTY

CERTAINTY that in the future, as in the past, LINDE's resources permit sound expansion and unquestioned ability to meet contractual obligations. CERTAINTY that LINDE facilities can provide dependable, effective back-up for emergency needs. CERTAINTY that LINDE's resources in personnel will always provide complete creative research and technical service.

LINDE COMPANY
DIVISION OF UNION CARBIDE CORPORATION

UNION CARBIDE

For more data on advertised products, use Readers' Service Cards, last page.

...A SIMPLE RULE-OF-THUMB THAT LETS YOU REDUCE PACKINGS INVENTORY ...AND STILL HANDLE 9 OUT OF 10 VALVE AND PUMP PACKING JOBS!

FOR VALVES, J-M THERMO-CORE® (black) offers excellent heat resistance, maximum sealing under least compression, and adapts readily to equipment variations. For general use, Style No. 397 is recommended. This style consists of Inconel-reinforced asbestos yarns . . . braided over a soft center core of graphite and 100% white asbestos.

FOR PUMPS, J-M CHEMPAC® (white) combines the excellent sealing and heat-resistant qualities of asbestos with Teflon's immunity to almost all chemical and solvent action. Chempac Style No. 2009 is recommended to give you long, efficient and economical service on the majority of your pump, expansion joint and agitator applications.

For special conditions – or for any other mechanical packings application you can name–Johns-Manville produces the industry's most complete range of packing styles. These are described in J-M's new 64-page Mechanical Packings Book. It is designed to help you select the packing best suited to each particular requirement. For a free copy of PK-131A, write to Johns-Manville, Box 14, New York 16, N. Y. In Canada, address Port Credit, Ontario. Cable address: Johnmanvil.

JOHNS-MANVILLE JM

For more data on advertised products, use Readers' Service Cards, last page.

from Japan at $557 million. This established a favorable U.S. trade balance of $88 million. Since the United States had a deficit with Japan of almost $17 million in the first half of 1959, the shift in the trade balance in this country's favor amounts to about $105 million. As noted, the dollar volume of petroleum export has a significant bearing on these figures.

In the first half of 1960 Japan was again the largest overseas market for the United States, as well as the second most important source of U.S. imports. To some extent the growth in exports is attributable to the over-all 1960 recovery of U.S. international trade. But exports to Japan have risen far more than U.S. exports in general. Though U.S. exports to all countries in the first half of 1960 were 21 percent greater than in the corresponding period of 1959, exports to Japan were 48.2 percent higher.

U.S. Crude Exports Drop 10,000 BPD in 1960

U.S. exports of crude and products declined in 1960 from 208,000 bpd in 1959 to 198,000 bpd, U.S. Census Bureau statistics show. Fourth quarter exports for 1960 averaged 182,000 bpd compared with 189,000 bpd for the same period in 1959.

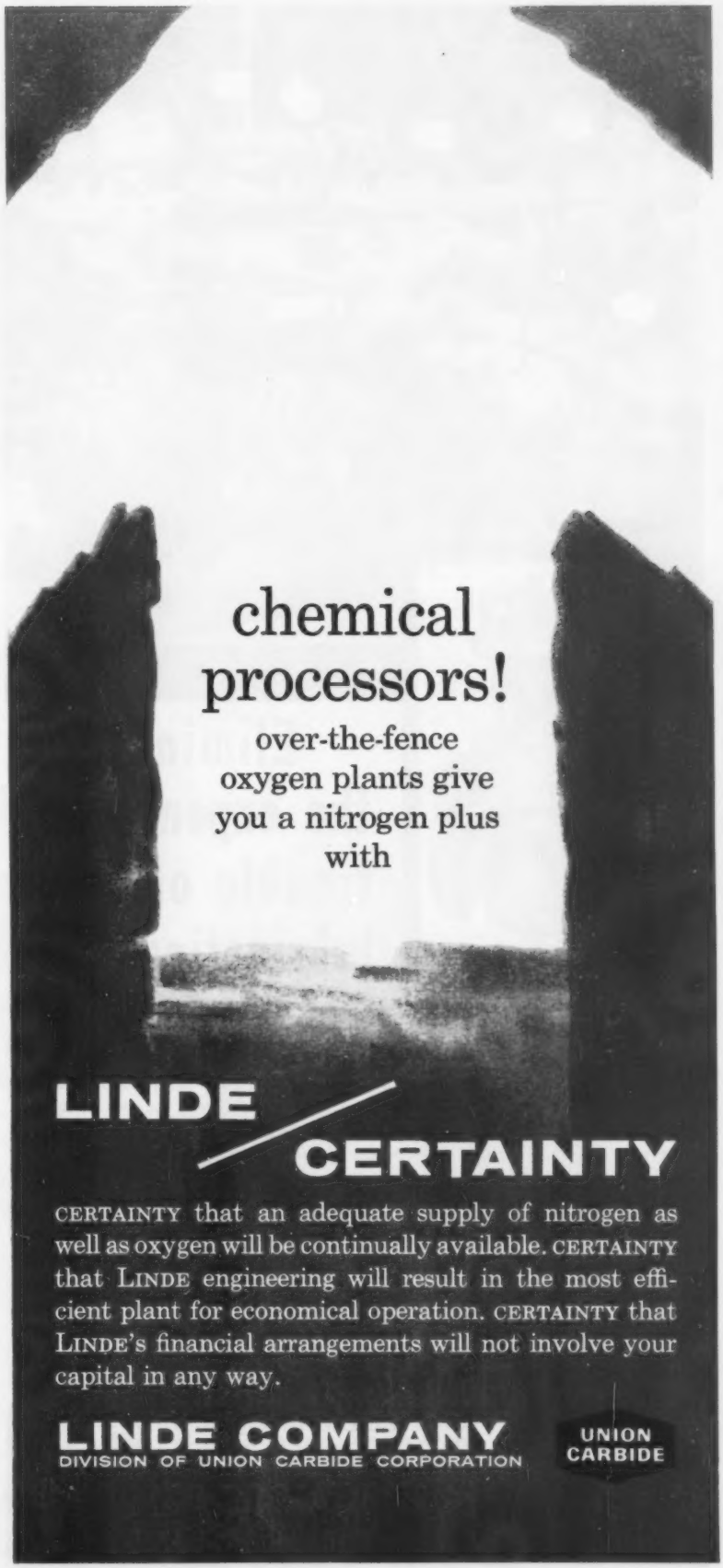
December 1960 had an export average of 182,000 bpd compared with 211,000 bpd in December 1959.

Phillips Additive Prevents Ice in Jet Fuel Systems

A new chemical additive which prevents in-flight ice formation in aircraft jet fuel systems has been developed by Phillips Petroleum Co., Bartlesville, Okla. It has successfully undergone exhaustive tests by the United States Air Force and the Boeing Airplane Co. The Air Force has approved its use by the Strategic Air Command.

Phillips developed the new compound with its own research funds. It is immediately available in sufficient quantities to meet the needs of military and commercial jet aircraft and guided missiles using jet fuel.

The new additive was chosen after elimination of hundreds of other candidates which were screened in extensive laboratory work. The compound has been proved satisfactory and effective in a year of flight tests in a B-52G at Boeing-Wichita and thousands of hours of tests in 15 B-52s and 10 KC-135 jet tankers of the 4043rd Strategic Wing, Wright-Patterson Air Force Base. The new additive is compatible with materials it contacts in the fuel systems. It does not adversely affect the thermal stability of jet fuel.


chemical
processors!
over-the-fence
oxygen plants give
you a nitrogen plus
with
LINDE
CERTAINTY
CERTAINTY that an adequate supply of nitrogen as well as oxygen will be continually available. CERTAINTY that LINDE engineering will result in the most efficient plant for economical operation. CERTAINTY that LINDE's financial arrangements will not involve your capital in any way.
LINDE COMPANY
DIVISION OF UNION CARBIDE CORPORATION
UNION CARBIDE

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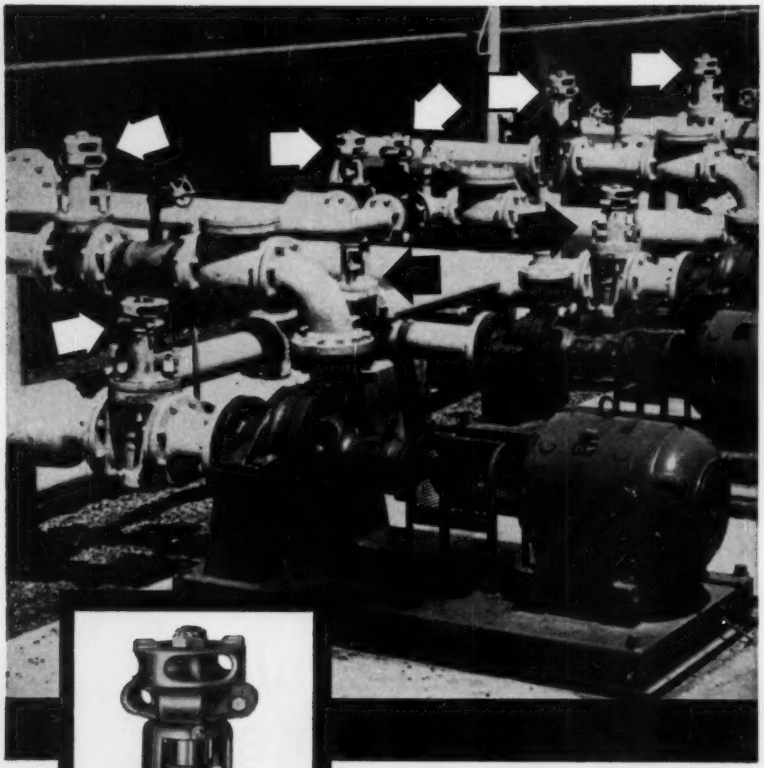

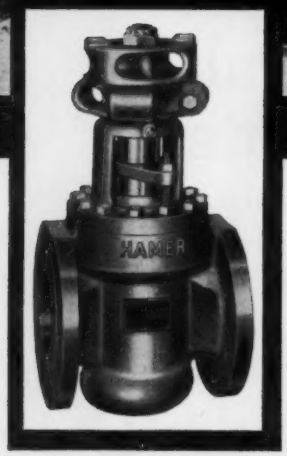

Eliminate the expense and trouble of valve lubrication with

HAMER PLUG VALVES

Hamer Plug Valves are unsurpassed for sure sealing, ease of operation and low maintenance cost. Being non-lubricated they not only eliminate the cost of lubrication but also prevent contamination of line product. The powerful plug adjusting nut acting as a screwjack is a positive means of raising and lowering the plug when operating the valve.

The plug and body seats are finished on special grinding machines and individually matched for precision fit, assuring smooth operation and perfect sealing.

Hamer Plug Valves are available in sizes 2" through 12" in working pressures to 600 lbs. W.O.G. Ask your Hamer Valve Specialist for complete specifications and applications of Hamer Plug Valves. Write for new catalog.

WECO

WELL EQUIPMENT MFG. CORP.
HOUSTON, TEXAS

Division of CHIKSAN COMPANY *a subsidiary of* FOOD MACHINERY AND CHEMICAL CORPORATION

HV-3-60

fmc

WECO UNIONS

CHIKSAN SWIVEL JOINTS

HAMER LINE BLIND VALVES

HAMER PLUG VALVES

- Changing Times -

Australia imported 884,365,000 gallons of crude oil in the quarter ending September 1960, compared with 724,325,000 gallons in the same quarter of 1959.

A grant of $700,000 is made to education by Socony Mobil Oil Co., Inc. The money assists fellowships and scholarships in 70 universities, supports research and maintains professorships.

Shell Chemical Co. and Reeves Brothers, Inc., enter agreement to develop polypropylene for use in the fiber field.

Gulf Oil Corp. moves its Refinery Technology Laboratory facilities at Girard Point to its main technical center near Pittsburgh, Pa.

American Petroleum Institute and Manufacturing Chemists' Association, Inc., move research projects on physical and thermodynamic properties of hydrocarbons from Carnegie Institute of Technology to Texas A. and M. College.

Britain's refining capacity reached about 980,000 bpd at the end of 1960, reports the Petroleum Information Bureau. The bureau said 80 percent of crude imports to Britain came from the Middle East.

Oil companies plan to build 135 million tons of annual refining capacity in the free world, excluding North America, within the next few years, reports the Petroleum Press Service.

U.S. and Puerto Rican licensed oil imports, excluding exempt overland imports from Canada, totaled 1,600,974 bpd in December.

Texaco, Inc., plans to discontinue operation at its 8,000-bpd Sunburst, Mont., refinery, according to E. W. Grogan, plant superintendent. The refinery "has been an uneconomic operation for some years," Grogan said.

Engineers' salary levels rise approximately 5 percent per year between 1958 and 1960 according to a survey by the Engineering Manpower Commission of Engineers Joint Council. The overall median annual salary presently stands at $9,600.

Engineering consultant firm, Frank H. Walk & Associates changes its name to Frank H. Walk, Gerald M. Haydel & Associates. The firm is located in New Orleans.

Relief work on behalf of refugees from communist-controlled Cuba is being aided by a $100,000 contribution from Texaco, Inc. The Castro regime last June seized $55 million of Texaco's Cuban assets.

Continental Oil Co. gives $200,000 to education program for 1961-62. The

NEW

EXPLOSION-PROOF,
DUST TIGHT, WEATHER-RESISTANT
MOTOR STARTER and
CIRCUIT BREAKER

PYLETS®

The Pyle-National Company announces their new series ECS threaded enclosure PYLETS, Model 60, for motor starters, circuit breakers and combinations. Designed for indoor and outdoor use in the most severe industrial environments. Class I, Groups C and D; Class II, Groups E, F, and G; and Class III (NEMA Types 3, 5, 7CD and 9EFG).

design features...

- INSIDE THREADED TOP DOME OUTSIDE THREADED BOTTOM DOME For True Weather Protection
- ACME SCREW THREAD CONSTRUCTION For Ease of Maintenance
- DOMES INTERLOCKED with BREAKER HANDLE For Increased Safety
- ALL ALUMINUM CASTINGS— STAINLESS STEEL EXTERIOR HARDWARE For Realistic Corrosion Resistance
- RUGGED OPERATING MECHANISMS For Longer Life
- ADJUSTABLE MOUNTING FRAMES For Simplified Stocking
- GLARE SHIELDED PILOT LIGHTS For Easier Observation

THE PYLE-NATIONAL COMPANY
1393 North Kostner Avenue **Chicago 51, Illinois**

BRANCH OFFICES AND REPRESENTATIVES in the Principal Cities of the United States
MANUFACTURED IN CANADA by Pyle-National (Canada) Ltd., Toronto 15
RAILROAD EXPORT DEPARTMENT: International Railway Supply Co., 30 Church Street, New York 7
INTER AMERICA EXPORT DEPT.: Lionel-Essex Inter America, Inc., 15 East 26th Street, New York 10

CONDUIT FITTINGS ▪ CIRCUIT CONTROLS ▪ LIGHTING FIXTURES ▪ FLOODLIGHTS

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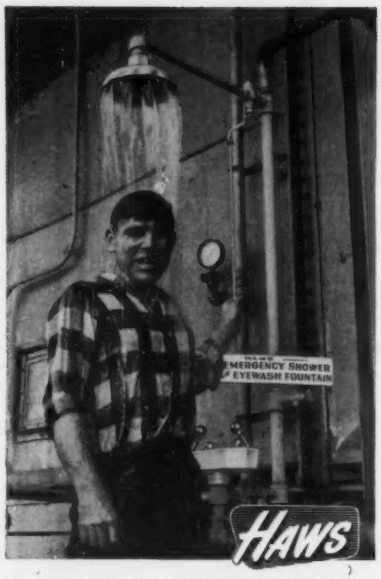
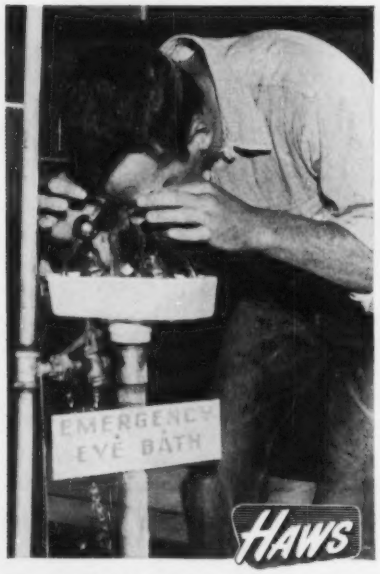


FLUSH AWAY CONTAMINATION

Haws Emergency Drench Showers instantly flood contaminated persons with a deluge of water, protecting against injury from caustic chemicals, vapors, acids or volatile fuels. Write today for Haws fully detailed safety catalog.

HAWS DRINKING FAUCET CO.
Fourth and Page Streets • Berkeley 10, Calif.



CONTAMINATED EYES SAVED

A Haws Eye-Wash Fountain instantly sends soothing water into injured eyes to wash away volatile fuels and acids. Accidents happen—but you can prevent serious damage. Write today for Haws fully detailed safety catalog. HAWS DRINKING FAUCET CO., *Fourth & Page Streets, Berkeley 10, California.*

Changing Times (continued)

company will award $3,000 fellowships for basic research at 21 schools and $500 scholarships to undergraduates at 28 colleges.

Italy signs up for about 80,000 bpd of Russian crude in 1961. Ente Nazionale Idrocarburi will get 54,000 bpd of the imports. Italy will export refining and petrochemicals equipment to Russia.

Meetings Calendar

Mar.	
13–17	**National Association of Corrosion Engineers,** Annual Meeting & Corrosion Show, Hotel Statler, Buffalo, N.Y.
15–17	**Natural Gasoline Association of America,** Annual Convention, The Baker Hotel, Dallas, Texas.
21–23	**American Power Conference,** Sherman Hotel, Chicago, Ill.
21–30	**American Chemical Society,** National Meeting, St. Louis, Mo.
26–29	**Texas Safety Association,** Annual Texas Safety Conference, Rice Hotel, Houston, Texas.
27–31	**Instrument Society of America,** Symposium on Temperature—Its Measurement and Control in Science and Industry, Veterans' Memorial Auditorium, Columbus, Ohio.
28–29	**Gas Conditioning Course,** University of Oklahoma, Norman, Okla.
April	
10–11	**American Society of Mechanical Engineers,** Maintenance & Plant Engineering Conference, Bancroft Hotel, Worcester, Mass.
10–12	**Western Petroleum Refiners' Association,** Annual Meeting, Grenada Hotel, San Antonio, Texas.
10–14	**Safety Engineering Course,** University of Oklahoma, Norman, Okla.
17–19	**ISA,** National Symposium on Instrumental Methods of Analysis, Shamrock-Hilton Hotel, Houston, Texas.
18–20	**American Welding Society,** Meeting and Show, Commodore Hotel, New York.
18–20	**Gas Measurement Short Course,** University of Oklahoma, Norman, Okla.
–28	**NGAA,** Oklahoma Regional Meeting, Lake Murray Lodge, Ardmore, Okla.
–30	**Liquefied Petroleum Gas Association,** Annual Convention, Conrad
May 3	Hilton Hotel, Chicago, Ill.
May	
2– 4	**Purdue Industrial Waste Conference.** Purdue Memorial Center, Purdue University, Lafayette, Ind.
8–10	**ISA,** National Power Instrumentation Symposium, LaSalle Hotel, Chicago, Ill.
8–11	**American Petroleum Institute,** Division of Refining, Midyear Meeting, Rice Hotel, Houston, Texas.
8–12	**API,** Accident Prevention and Fire Protection Meetings, Statler-Hilton Hotel, Detroit, Mich.
11–13	**American Institute of Industrial Engineers,** National Conference & Convention, Sheraton Cadillac Hotel, Detroit, Mich.
15–19	**National Fire Protection Association,** Annual Meeting, Statler Hotel, Detroit, Mich.
17–19	**WPRA,** Mid-Continent Regional Technical-Industrial Relations Meeting. Hotel Lassen, Wichita, Kan.
–19	**NGAA,** Permian Basin Regional Meeting, Lincoln Hotel, Odessa, Texas.
22–24	**ISA, AIEE, ARS, IAS, IRE,** National Telemetering Conference, Chicago.
22–25	**ASME,** Design Engineering Conference & Show, Cobo Hall, Detroit, Mich.
24–25	**WPRA,** Computer Conference for Refiners, Benjamin Franklin Hotel, Philadelphia, Pa.
June	
5– 6	**Petroleum Electric Power Association,** Meeting, Mayo Hotel, Tulsa, Okla.
6– 8	**ISA,** Summer Instrument-Automation Conference & Exhibit, Royal York Hotel, Queen Elizabeth Hall, Toronto, Ont.
11–15	**ASME,** Summer Annual Meeting, Statler Hilton Hotel, Los Angeles, Calif.
–12	**ISA,** Air Pollution Control Association, Air Pollution Instrumentation Symposium, Hotel Commodore, New York City.
13–16	**ISA,** Gas Chromatography Symposium, Kellogg Center, Michigan State University, East Lansing, Mich.
28–30	**American Association of Cost Engineers,** Annual Meeting, Boston, Mass.
28–30	**ISA, AIChE, AIEE, ASME, IRE,** Automatic Control Conference, University of Colorado, Boulder, Col.
Aug.	
28–Sept. 1	**ASME,** International Heat Transfer Conference, University of Colorado, Boulder, Colo.
Sept.	
5– 8	**ACS,** National Chemical Exposition, Chicago Amphitheater, Chicago, Ill.
11–15	**ISA,** Fall Instrument-Automation Conference & Exhibit, Biltmore Hotel, Memorial Sports Arena, Los Angeles, Calif.
–14	**NGAA,** Rocky Mountain Regional Meeting, Northern Hotel, Billings, Mont.
20–21	**WPRA,** Rocky Mountain Regional Technical-Industrial Relations Meeting, Henning Hotel, Casper, Wyo.

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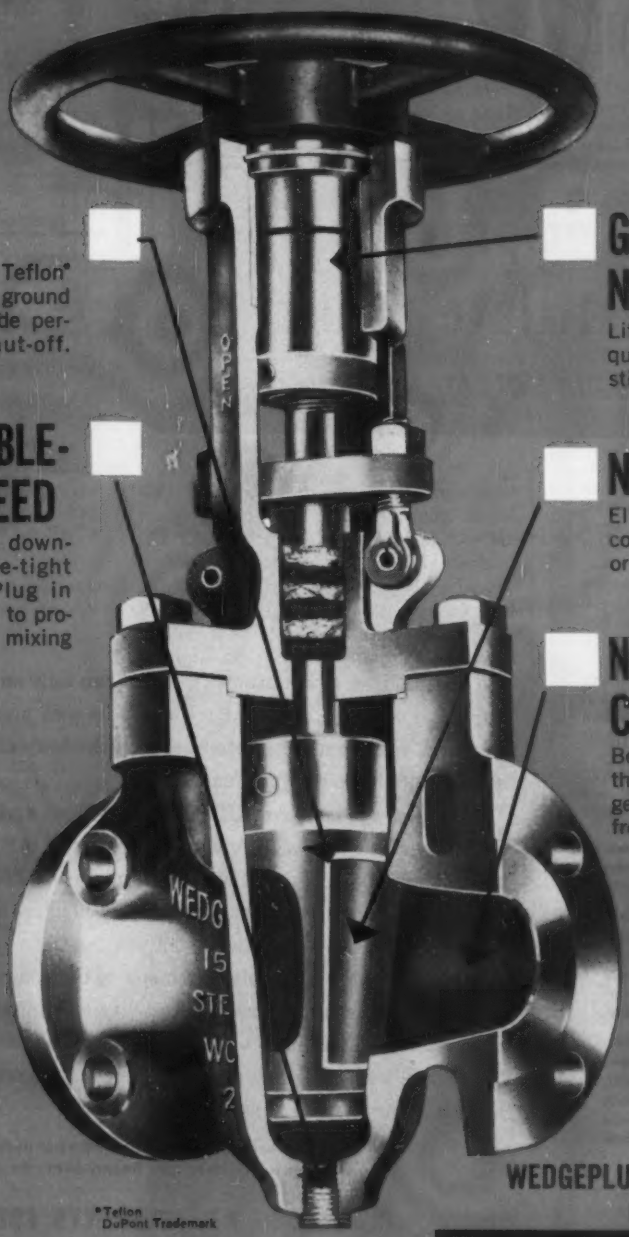
CHECK THE WAYS

YOU'LL SAVE MONEY

WITH STOCKHAM'S WEDGEPLUG O-SEAL VALVE



NO LEAKAGE

Pressure-sealing effect of Teflon* "O" rings in the plug plus ground metal-to-metal seats provide permanent bubble-tight shut-off. Safe in case of fire.

PROVIDES DOUBLE-BLOCK AND BLEED

Both the upstream and downstream seats hold bubble-tight against line pressure. Plug in bottom-boss can be pulled to provide bleed. Absolutely no mixing of products on manifolds.

GUARANTEED NOT TO STICK

Lift-type plug engineered for quick, easy operation. Will not stick.

NO LUBRICATION

Eliminates the high monthly cost of lubricants and labor, or a lubricating service.

NO PRODUCT CONTAMINATION

Because it's non-lubricated, the O-Seal eliminates the danger of product contamination from plug seal lubricants.

*Teflon
DuPont Trademark

AVAILABLE THROUGH YOUR LOCAL STOCKHAM DISTRIBUTOR

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DIVISION OF

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VALVES *and* FITTINGS

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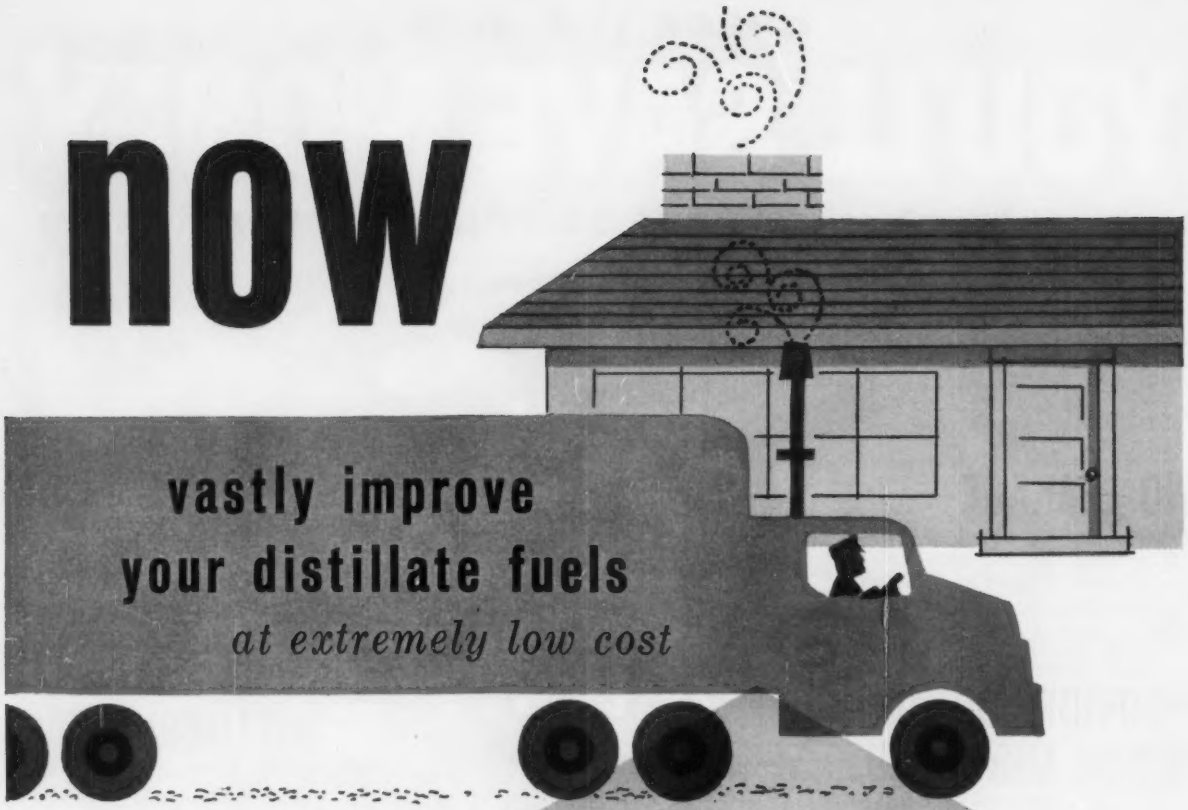


vastly improve your distillate fuels

at extremely low cost

UOP INHIBITORS AND ADDITIVES FOR TREATMENT OF DISTILLATE FUELS

POLYFLO™ *inhibitor-dispersants: Made in three formulations. Stabilize against thermal changes, color deterioration, sludge and deposit formation.*

DRIACIN® *dispersant-additive: Specially formulated for unstable heating and diesel fuels. Limits growth of colloidal particles, prevents clogging of filters, formation of rust in storage tanks.*

UOP COPPER DEACTIVATORS *: Two grades—80% and 50% active ingredient. Prevent trace copper interfering with action of inhibitors. Minimize color and sediment deterioration.*

No one inhibitor or inhibitor-dispersant can fully and effectively protect *every type* of distillate fuel. Each needs its own proper inhibitor selection, which must be determined on the basis of a comprehensive analysis of the fuel to be treated.

In response to this need, UOP offers a unique and highly valuable service that includes determining your precise inhibitor needs, based upon inspection and study of your fuels. From this analysis, we will determine the best inhibitor or most effective inhibitor blend recommended for each type of fuel you market.

Use of the correct inhibitor or blend of inhibitors for a given distillate fuel assures maximum stability at minimum cost. Reduced concentration of inhibitors also minimizes water absorption.

Refiners with distillate fuel marketing problems will find this service a must!

For our recommendations, send your distillate fuel samples to our Products Department—no obligation.

UNIVERSAL OIL PRODUCTS COMPANY
30 Algonquin Road
Des Plaines, Ill., U.S.A.

UOP®

WHERE RESEARCH TODAY MEANS PROGRESS TOMORROW

Men in HPI...

I. G. Davis and J. E. Bounds have been elected executive vice presidents,

Davis

Bounds

Dorsey

Gulf Oil Corp. Davis was previously a senior vice president, and Bounds was administrative vice president and coordinator, Financial Department. **B. R. Dorsey,** formerly administrative vice president and coordinator, Manufacturing Department, has been named senior vice president. He will head the general areas of refining, petrochemicals and product supply.

Edward J. Steinmetz has been named assistant director of the Management Engineering Department, Ashland Oil & Refining Co. Steinmetz will continue as manager of the company's methods and procedures section, the position he held at the time of his promotion.

Carl E. Reistle, Jr., Houston, executive vice president, Humble Oil & Refining Co., has been elected to honorary membership in the American Institute of Mining, Metallurgical, and Petroleum Engineers.

A. G. Pollard, formerly refinery superintendent, Tennessee Oil Refining Co.'s Chalmette, La., refinery, has been promoted to refinery manager to handle broad supervision, organization and planning. Succeeding Pollard as refinery superintendent is **C. H. Kilgore,** formerly operating superintendent. Kilgore will be in charge of operation and maintenance, **R. L. Hanle** has been named head of the refinery's Products Division, responsible for refinery coordination, oil movements and laboratory and blending operations.

Louis W. Gardner has been appointed director of the Geophysical Research Division, Gulf Research & Development Co., a subsidiary of Gulf Oil Corp. He will supervise the company's research work in geophysics. He succeeds **Dr. T. J. O'Donnell,** who has been named associate director of the Gulf Laboratories.

A. W. Pryor has been promoted to senior research engineer in process and plant design, Richmond Laboratory, California Research Corp. Pryor studied chemical engineering at Kansas State University and Massachusetts Institute of Technology where he received an M.S. degree. He joined the company in 1947 and was assigned to process and plant design work in 1954. He is recognized as an expert in furnace and catalytic cracker design, particularly those features important to moving or fluidized bed operation.

Ernest E. Ludwig has been named manager of process engineering, Rexall Chemical Co., division of Rexall Drug and Chemical Co. Ludwig is also project manager for Rexall's polyolefin project in Odessa, Texas. He was a co-author of the article "Rate Exchangers This Computer Way," published in Vol. 40, No. 1, PETROLEUM REFINER.

Dr. Gilbert B. Carpenter has been named technical adviser, Socony Mobil Oil Co, Inc.'s, Mobil Chemical Co. He will headquarter at Mobil Oil Nederland N.V., Rotterdam, Holland. He will advise Mobil Chemical on the expansion of its chemical production and research activities in the United States and abroad.

H. A. Francis has been appointed to refiner-production, Light Oil Division, Standard Oil Co. of California, El Segundo refinery. **R. A. Diepenbrock,** formerly with Standard-California's Bakersfield refinery, will succeed Francis as assistant superintendent, Package and Utilities Division, El Segundo. Replacing Diepenbrock as refiner at Bakersfield is **T. G. Lawrence.**

Harry A. Jarvis has succeeded **Arthur T. Proudfit** as president of Creole Petroleum Corp. **Leo E. Lowry** has been elected executive vice president, the position held by Jarvis. Jarvis has been with Creole for 14 years, coming to Caracas, Venezuela, from Argentina where he had

Jarvis

Lowry

. . . one of a series presented by Western Supply Company, Tulsa, to improve the "I. Q."* of engineers . . . (*"Income Quotient")

IMPACT A RESULT OF CONTACT: PUBLIC SPEAKING NOT AN END, BUT A VITAL MEANS TO AN END

There certainly is no better tool in developing executive or management qualifications than through public speaking. Spoken words are a powerful tool of business. They are used to organize, motivate, coordinate, control, and train.

Since an executive must achieve results through people, he must be able to plan and organize. As a leader, he must be able to motivate and inspire people to action; he must make himself understood. He must have purpose and the will to make other people aid that purpose.

A speaker, too, achieves his results through people. He, too, must be able to plan and organize; must lead; must be able to motivate and inspire others to action; must make himself understood. The speaker must have a purpose and the will to make others aid that purpose. The skills of the executive are identical with those of a speaker, in these areas.

It is not surprising, then, that aspiring leaders in business and industry are judged by their associates and superiors by their abilities to communicate, to a great extent. It is not surprising that an executive can sell himself, can attain greater authority by broadening his capacities for directing and leading, through oral communication.

Words have great power, particularly the spoken word. Words give you contact with other men, and if you use them effectively, they give you—*impact.* That impact is multiplied as you develop your ability to speak, and as you speak to more important audiences.

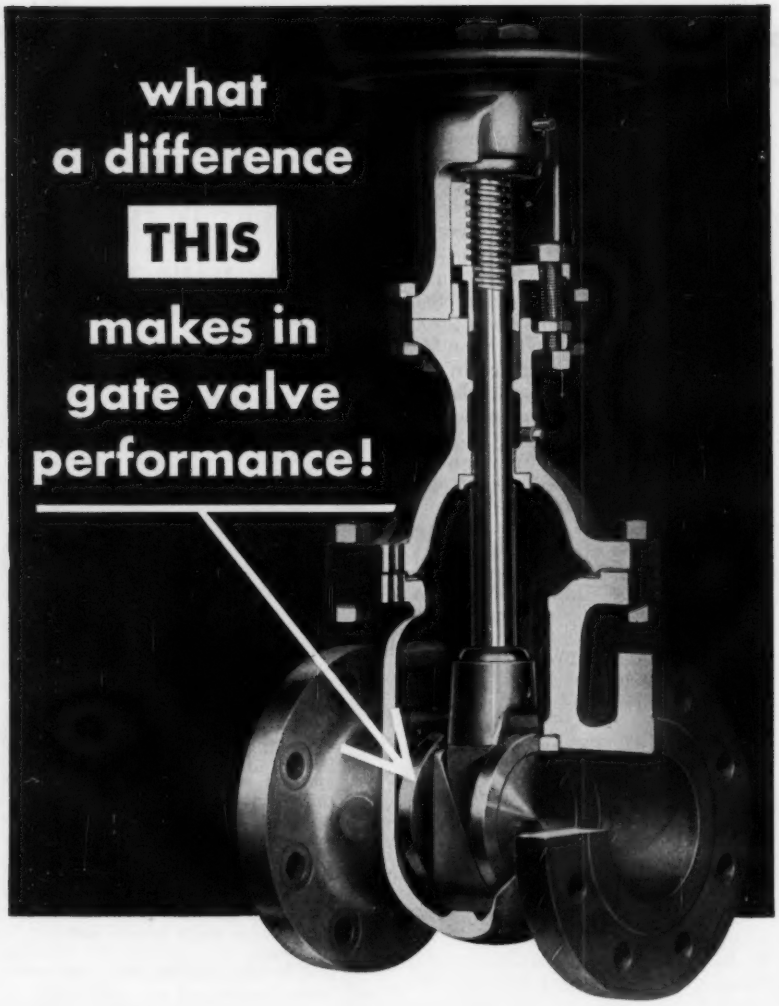
If you are a novice in public speaking you are not alone. No more than 25 per cent of our speakers could qualify as "veterans."

Like conversation, speaking before an audience is based on sincerity and belief. It involves conviction and concern. The public speaker is most convincing when he is least artful, when he is most natural, and above all, when he is sincere.

Effective speaking is not an accident. It is not the special endowment of a few. While talking before many listeners may come naturally for a few, it is, by and large, a learned art. It consists of an idea, phrased simply, and delivered with conviction and with an expressive voice.

FOOTNOTE: the foregoing paragraphs are a direct quotation from another of Western's "personal-professional development" series. Booklet E-8, titled "Public Speaking: Impact A Result of Contact" a copy of which is yours upon request, without obligation. Write to WESTERN SUPPLY COMPANY, HEAT EXCHANGER DIVISION, P. O. Box 1888, Tulsa, Okla. — **where supervision contributes greatly to the manufacture of heat exchangers of the highest quality, and where personal attention to detail is our watchword.**

For more data on advertised products, use Readers' Service Cards, last page.

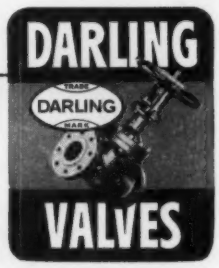


LONGER valve life, less maintenance and process interruption, positive closure, easier operation, self-adjustment for valve body deflection. These are some of the well proved advantages gained as a result of the Darling *fully revolving double disc parallel seat* principle!

These Darling valves are made in various alloys, types and sizes for most services . . . and for all pressures. Send for Catalog No. 57. You'll see what we mean by exceptional performance.

ENGINEERING SERVICE: Darling offers unusual facilities for the development and manufacture of special valves for out-of-the-ordinary requirements. This special service is available to you at all times, without obligation.

DARLING VALVE & MANUFACTURING CO.
Williamsport 31, Pa.
Manufactured in Canada by
Sandilands Valve Manufacturing Co., Ltd., Galt 19, Ont.



Men . . .

worked 16 years with another Jersey affiliated company. He was the first manager of the Amuay refinery. Lowry, who is a specialist in finance, has been with Creole for 22 years. He came to Venezuela in 1938 from the United States and has held a series of positions in the Comptroller's Department, including the post of comptroller. In 1953, he was elected to the board of directors of the company.

Dr. Hugh B. Ogburn has been named manager, Process Engineering Department, The M. W. Kellogg Co., New York. Dr. Ogburn will be responsible for the economic and technical evaluation and development of process designs for petrochemical plants and oil refineries. He graduated from Princeton University, and formerly was director of the mathematics and kinetics section of the Research and Development Department, The Atlantic Refining Co. An authority on the application of computers to scientific and business problems, his responsibilities included research and applications work in the fields of catalysis, kinetics, process analysis, and operations research.

Ogburn

E. Duer Reeves, director and vice president, Humble Oil & Refining Co., Houston, has been elected to the board of directors, Esso Research and Engineering Co. Others named to the board are: **F. A. L. Holloway,** vice president, manufacturing, Humble Oil, Houston; and **Loren F. Kahle,** transportation coordinator, Standard Oil Co. (New Jersey), New York.

Dr. Edward G. Baker has been appointed a senior research associate by the executive committee of Esso Research and Engineering Co. Dr. Baker joined Esso Research in 1951, soon after he earned a doctorate in physical chemistry from Brown University.

Roy M. Webber, personnel director of Monsanto Chemical Co.'s William G. Krummrich plant at Monsanto, Ill., has been appointed employe relations manager for the company's Organic Chemicals Division, St. Louis.

George W. Jandacek, assistant to the manager of DX Sunray Oil Co.'s refinery in Duncan, Okla., has been named general manager of the Suntide Refining Co. plant in Corpus Christi. **J. L. Laird** will remain plant manager at Suntide. Before being transferred to

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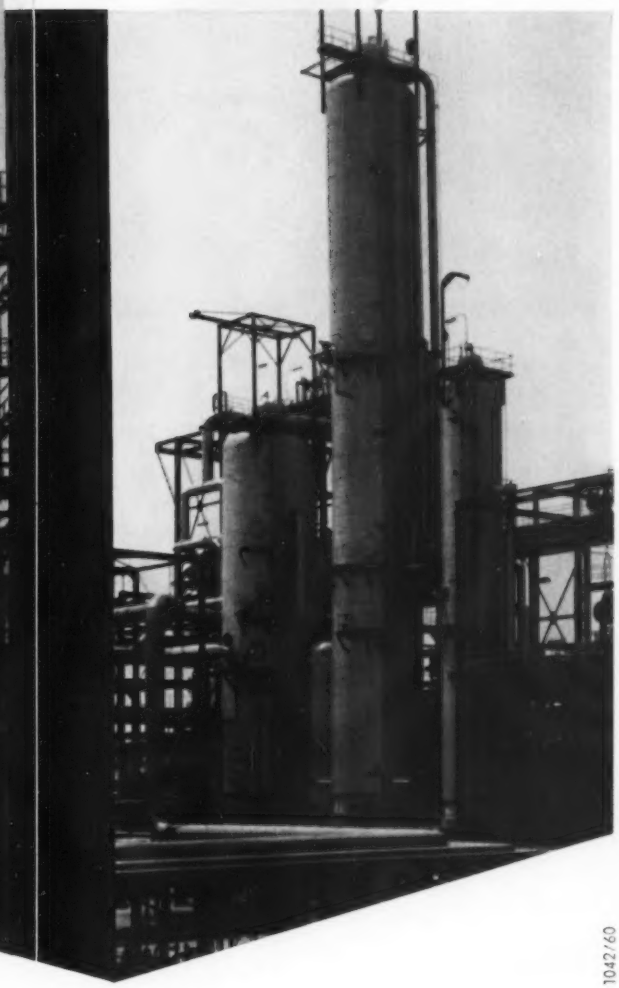
In 1959 we supplied to and erected on behalf of the Deutsche Shell AG. for their Godorf Refinery the

Distillation Unit
Gas Recovery Unit
Absorber Unit
Heat Exchangers and
Structural Steelwork.

Design and engineering work was carried out by the Bataafsche Petroleum Maatschappij N.V. and the Comprimo N.V., The Hague, whereas matters relating to purchase and inspection were attended to by Edeleanu GmbH., Frankfurt.

Our range of products also includes spherical tanks, pressure vessels and accessories for nuclear power stations, air coolers and regenerative heaters.



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"We deliver too"

What's so special about the huge fractionating tower shown here? It is one more example of how Sun Ship builds and delivers heavy industrial equipment on barges or sea-going vessels, with careful attention to such requirements as safety and on-time schedule.

Whether it's a fractionating tower or key structural part for industry, transporting big items by water or by rail is strictly routine for Sun Ship, for we build and deliver what's needed in many fields. If you have a machinery or heavy equipment problem, write to us about it.

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ON THE DELAWARE • SINCE 1916 • CHESTER, PA.

For more data on advertised products, use Readers' Service Cards, last page.

Men . . .

the Duncan refinery, Jandacek was manager of operations coordination in the Manufacturing Department's main offices in Tulsa. He joined DX Sunray in 1953 as a chemical engineer.

C. L. Parris has been named manager of Amoco Chemicals Corp.'s Haverhill, Ohio, plant. **Jerald D. Reed** has been appointed plant manager at Joliet, Ill., succeeding Parris. **Fred F. Diwoky** has replaced Reed as manager of the company's Texas City plant. Parris has been plant manager of Amoco's aromatic acids plant at Joliet since 1957. Reed has served as manager of the Texas City plant since 1957 and has been with petrochemical operations of affiliated companies. For the past three years, Diwoky has been assistant to the general manager, manufacturing, Amoco Chemicals, Chicago.

Parris

Reed

Diwoky

B. C. Shaul has been appointed assistant division manufacturing manager, Tidewater Oil Co.'s Western Division. Shaul, who received his B.S. degree from the University of California (Berkeley) in 1929, joined the company the same year as an engineer at the Avon refinery. Prior to receiving his new assignment, he was general superintendent of the Flying A refinery's Manufacturing Department.

J. R. Eck has been appointed assistant general manager of Monsanto Chemical Co.'s Plastics Division, Springfield, Mass., after serving as president of Mobay Chemical Co. at Pittsburgh. Mobay is owned jointly by Monsanto and Farbenfabriken Bayer A.G. of West Germany.

L. G. (Gayle) Rodgers, manager of engineering for Sunray Mid-Continent Oil Co., has been named vice president of Sunray Chemical Co. After graduation from the University of Tulsa in 1939, Rodgers became a process engineer and a manufacturing engineer, serving with two other major companies. He joined Sunray in 1948, serving in several

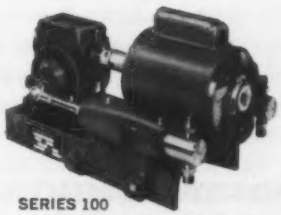
ACCURATE CHEMICAL FEEDING

from .65 gph to 1624 gph

SERIES 200
Self-contained lubricating system—no downtime for lubrication. E.Z. Clean Cartridge liquid end simplifies maintenance. Simplex models pump up to 812 gph at a maximum pressure of 10,000 psi. Duplex models double that capacity.

American controlled capacity proportioning pumps have repetitive metering accuracy of plus or minus 1%, when operating between 10% and 100% of capacity. Feed precisely metered fluids or slurries in virtually all ratios, with flow, temperature, pressure, conductivity, pH and other controlled process variables.

- interchangeable liquid ends
- spherical self-aligning bearings on crank and crosshead handle greater radial and axial thrust loads
- crossheads of hardened and ground steel ride on cast iron
- nylon dust covers protect bearing surfaces
- NEMA frame motors
- heavy duty reducers



SERIES 100
Simplex models pump up to 13.10 gph at a maximum pressure of 1000 psi. Duplex models double that capacity.

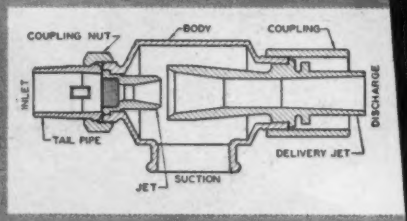
AMERICAN® METER COMPANY
INCORPORATED (ESTABLISHED 1836)
pump division
13500 PHILMONT AVE., PHILADELPHIA 16, PENNA.

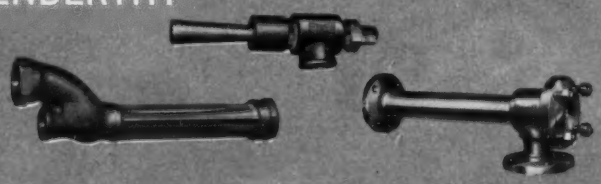
For more data on advertised products, use Readers' Service Cards, last page.

SIMPLICITY

For trouble-free operation

JET PUMPS by PENBERTHY





If you have a liquid heating, circulating, aerating, agitating, pumping or blending application (to mention a few), you'll find, chances are, that there just isn't a more economical, efficient, trouble-free device for handling the job than a Penberthy Jet Pump. They cost little to buy, little to install. And maintenance? Practically non-existent, for there are no moving parts, no packing glands, nothing to lubricate.

Penberthy, what's more, as the #1 name in Jet Pumps . . . with almost 70 years' experience in the field . . . offers you the broadest available selection of models, standard or special, steam, air or liquid operated, in a variety of materials. Ask a Penberthy engineer for assistance with your jet pump application.

PENBERTHY MANUFACTURING COMPANY
Division of Buffalo-Eclipse Corporation
PROPHETSTOWN, ILLINOIS
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Dedicated to Quality Since 1886

PENBERTHY FOR LIQUID LEVEL GAGE SETS, TOO

WRITE OR CALL PENBERTHY TODAY FOR COMPLETE INFORMATION

Men . . .

managerial and operating positions with both Sunray Mid-Continent and its refining and marketing subsidiary, DX Sunray Oil Co.

W. F. Jordan and C. A. Hill have been named vice presidents, Firestone Synthetic Rubber & Latex Co. In their new posts, Jordan and Hill will be responsible for the sales and production of

Jordan

Hill

synthetic rubber from company plants in Akron, Ohio; Lake Charles, La.; and a new plant at the Petrochemical Center, Orange, Texas.

N. D. Griswold has been named head of The Dow Chemical Co.'s Engineering and Construction Division, Houston. The division handles engineering work and construction administration for Dow's Texas, Louisiana, Brazos Oil and Gas, and Dowell divisions.

A. J. Bevevino has been named assistant manager, Sonneborn Chemical and Refining Corp.'s Petrolia, Pa., refinery. Bevevino joined the refinery staff 19 years ago, and since then has been plant engineer, research engineer, and plant superintendent. He was previously with Waverly Oil Works Co., Pittsburgh, and Conewango Refining Co., Warren, Pa.

John A. McCone has been elected a director of Standard Oil Co. of California. McCone was chairman of the Atomic Energy Commission in the Eisenhower administration. He succeeds **Robert Watt Miller,** who resigned in December.

Josaphat Marinho has been named head of Brazil's National Petroleum Council. He was appointed by President Quadros, who also named **Geonisio Barroso** as the new president of Petroleo Brasileiro (Petrobras).

Philip D. Croll has been appointed manager, Editorial Services Division, Sun Oil Co.'s Public Relations Department. Croll succeeds **George J. Bauer, Jr.,** who retired after 41 years with Sun.

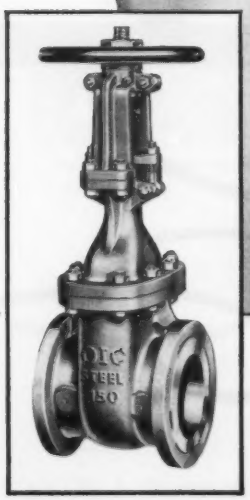
Carl Illig will succeed **Forrest M. Darrough** as associate general counsel of Humble Oil & Refining Co., principal operating affiliate of Standard Oil Co.

For more data on advertised products, use Readers' Service Cards, last page.

Every day... more and MORE oil companies turn to OIC valves

. . . because OIC has developed valves to solve the special problems of the oil and gas industry . . . valves built for continuous operation and lower maintenance cost. A variety of experience-proved materials and designs are available to meet the exacting needs of this industry in the field, in the refinery and gasoline plants wherever oil and hydrocarbons are being produced, processed or transported. Standard valve trims are available for highly corrosive and severe pressure-temperature operating conditions. Get acquainted with your local OIC distributor. He is equipped to help you with all your valve problems.

BETTER VALVES AND BETTER SERVICE FROM OIC DISTRIBUTORS



INDUSTRIAL DISTRIBUTORS · SERVING INDUSTRY ECONOMICALLY · THE RIGHT HAND OF PRODUCTION

OIC VALVES

FORGED STEEL, CAST STEEL, BRONZE, IRON AND DUCTILE IRON VALVES

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THE OHIO INJECTOR COMPANY
271 Main Street, Wadsworth, Ohio
Please send more information about
Iron ( ) Bronze ( ) Steel ( ) Ductile Iron ( ) Valves.

Name_____

Company_____

Street_____

City_____ Zone_____ State_____

Men . . .

(New Jersey). Illig moves to the headquarters staff of Humble Co. from Humble Division, where he has been serving as division general counsel and a member of the board of management. He joined Humble in 1934.

E. F. Bullard, and L. W. Moore have been elected to the board of directors, Standard Oil Co. (Indiana). Bullard is chairman, Pan American Petroleum Co., and Moore is president, American Oil Co.

Joe E. King, former senior vice president of Tennessee Gas Transmission Co., has been elected president, Tenneco Chemical Co. **F. L. Padgitt,** formerly director of project development at Tennessee Gas, has been named Tenneco Chemical vice president. Tenneco Chemical, a division of Tennessee Gas Transmission, plans to build and operate a large petrochemical complex on the Houston Ship Channel.

King

Tom V. McGannon, Economics Department supervisor, American Oil Co.'s Texas City refinery, has been transferred to Chicago as assistant manager of light oil supply-planning. **Calvin E. Sparks,** division supervisor of the Coordination and Economics Department, has been promoted to department supervisor, replacing McGannon. **Ernest J. Brinkman** has been named division supervisor of the department, succeeding, Sparks.

Dr. R. G. Minet has joined the staff of the experimental coke project jointly owned and operated by Food Machinery and Chemical Corp. and United States Steel Corp. He will be assistant to the project manager and will be located in FMC's New York office. Formerly chief process engineer for United Engineers and Constructors, Dr. Minet was project engineer for the design and construction of the Kemmerer, Wyo., coke plant.

Charles R. Hirt, Procter & Gamble Co., Cincinnati, has been elected president, American Association of Cost Engineers. The new vice president is **William G. Clark,** The Dow Chemical Co., Pittsburgh. **Thomas C. Ponder,** petrochemicals editor, PETROLEUM REFINER, has been named secretary, and **Cecil H. Chilton,** McGraw-Hill Publishing Co., New York, has been appointed treasurer.

Ralph C. Medhurst has been appointed a project chemist in the Research and Development Department American Oil Co. Since he joined the company in 1958, Medhurst has specialized in investigating patent literature for developments of interest in petroleum research.

John D. Epperson has been appointed staff representative, National Safety Council, petroleum section. Before joining the council, Epperson was safety director and assistant personnel director for Rockwell-Standard Corp., Mishawaka, Ind.

K. R. Gerhart, Houston, has been promoted to manager of manufacturing, Continental Oil Co.'s Petrochemical Department. **J. D. Burns,** formerly assistant superintendent of the Gretna, La., petrochemical plant, has been promoted to technical assistant to the manager of petrochemical manufacturing, with headquarters in Houston.

Joseph T. Wilson, Jr., has been elected a director and secretary-treasurer of Sun Oil Co. He succeeds **John C. Agnew,** who retired. Wilson's former post as assistant secretary-treasurer will be taken by **William S. Woods, Jr.,** previously manager of the Treasury Department's Financial and Corporate Stock Division and an assistant secretary-treasurer.

Dr. William E. Kennel has been elected to the board of directors, Amoco Chemicals Corp. Kennel is manager of research for Amoco Chemicals.

H. D. Kinsey has been elected a vice president of Union Carbide Corp. **Paul L. Alspaugh** has been appointed president of Union Carbide Olefins Co., a

division of the corporation. Kinsey, who will handle planning, organization and evaluation of various technical programs, joined Union Carbide in 1924 at the Clendenin, W. Va., plant. Alspaugh joined Union Carbide in 1928 at the South Charleston, W. Va., plant.

H. E. Lore, manager of the Machinery Division, Dravo Corp., Pittsburgh, has been elected president, National Constructors Association. The association is composed of nationally known engineering and construction firms engaged in designing and building steel, chemical, petroleum and power plants. **George Collins,** a vice president of Lummus Co. of New York, was named association vice president.

Joseph H. Sydnor, Jr., has been named to an administrative post in the Employe Relations Division, Esso Research and Engineering Co. Sydnor, who will act as compensation administrator, is responsible for activities involving salary administration, salary analysis and job classification.

P. C. Livesay, manager of the Standard Oil Co. (Indiana) Sugar Creek, Mo., refinery, has been appointed coordinator of manufacturing and purchasing of Soind.

THE "COMMON SENSE" SYSTEM THAT BEATS BEING THERE

Chemical-Petroleum users of Diamond Utiliscope Closed-Circuit Television frequently call it the "common-sense" system. Why? Simply because Diamond Electronics specialists design *every* Utiliscope system for the particular demands of the intended application. As a result, Utiliscope beats being there . . . will provide accurate, dependable, and safe viewing of all kinds of operations and equipment. To mention a few: conveyor systems, off-shore drilling, in-plant vehicle movement, explosive and radio active materials handling, furnaces, boilers, kilns, rocket test stands, instruments, perimeter barriers, plant entrances, and finished products.

Let us *show* you how Diamond Utiliscope assures more effective control, greater safety, and reduced operating costs. Send us the coupon. We'll be happy to provide complete information.

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Please send complete information on how Diamond Utiliscope can help reduce operating costs and improve operations.

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E. R. Baker, Houston, has been promoted to general manager of Continental Oil Co.'s Research and Development Department and Petrochemical Department. Formerly general manager of the Petrochemical Department, he will continue to make his headquarters in Houston. **W. F. Brown,** Houston, has been named manager of petrochemical planning, and **P. E. Geiser,** also of Houston, has been appointed general manager of petrochemical operations. Brown was formerly special assistant to the senior vice president, while Geiser was general manager of petrochemical manufacturing. **Dr. M. L. Sharrah,** Ponca City, will continue as manager of the Research and Development Department.

Baker

Lee Loevinger has been named assistant attorney general to head the U.S. Justice Department's Antitrust Division. Loevinger, appointed by President Kennedy, is an associate justice of the Minnesota Supreme Court.

Roger K. Fisher has joined the Research and Development Department, American Oil Co. His research will be aimed at elucidating the complex chemistry of such conversion processes as catalytic cracking.

John T. McCoy, coordinator of Tidewater Oil Co.'s Eastern Division Manufacturing Department, has been elected president of the Coordinating Research Council, Inc. **E. C. Belefski,** assistant treasurer of the American Petroleum Institute, was reelected treasurer of the council.

Dr. Elwood F. Booth, Jr., has been appointed assistant director of research, Solvay Process Division, Allied Chemical Corp. **Dr. Edward R. Degginger** has been named research supervisor, and **Dr. Michael J. Skrypa** becomes associate research supervisor. Dr. Booth joined Solvay in 1951, and has been assistant chief engineer and assistant manager of the Syracuse, N. Y., plant. Dr. Degginger has been with Solvay's Research Department since 1952. Dr. Skrypa has been with Solvay for about eight years. He was a senior research chemist.

Charles W. Pace has been appointed chief engineer, Ehrhart & Associates, Inc., engineers and constructors. He will headquarter in the Los Angeles office. **O. Lyle Wainwright, Jr.,** has been transferred from Los Angeles to San Francisco as manager of E & A's Bay area office.

Lawrence C. Brunstrum has been appointed senior research associate, Research and Development Department, American Oil Co., Whiting, Ind. Brunstrum will lead research on the rheology

For more data on advertised products, use Readers' Service Cards, last page.

BALL VALVES

PACIFIC OFFERS A COMPLETE LINE!

Engineered for exceptional performance, sound economy and trouble-free operation, PACIFIC BALL VALVES provide the practical answer to complex media handling problems today. Smooth quarter turn operation assures low operating torques. Straight thru flow, round ports contribute to high flow efficiency. Exclusive ball seal design affords the optimum for tight closures. Catalog BV-60 explains the benefits you may expect from the most advanced line of ball valves available to the industry today.

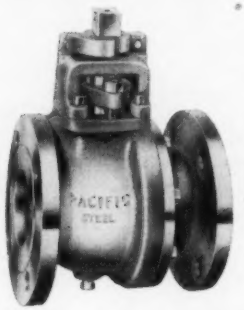

Fig. No. 400
Flanged Ends
150 lb. Series
Sizes – 2½" thru 12"

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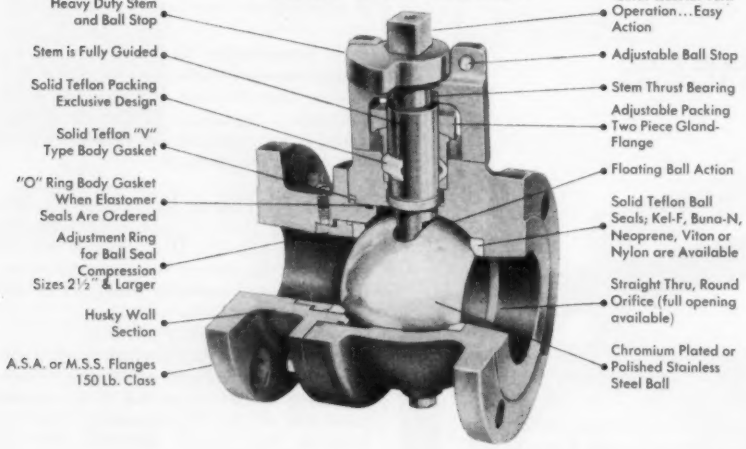

Heavy Duty Stem and Ball Stop
Stem is Fully Guided
Solid Teflon Packing Exclusive Design
Solid Teflon "V" Type Body Gasket
"O" Ring Body Gasket When Elastomer Seals Are Ordered
Adjustment Ring for Ball Seal Compression Sizes 2½" & Larger
Husky Wall Section
A.S.A. or M.S.S. Flanges 150 Lb. Class
Quick Quarter Turn Operation...Easy Action
Adjustable Ball Stop
Stem Thrust Bearing
Adjustable Packing Two Piece Gland-Flange
Floating Ball Action
Solid Teflon Ball Seals; Kel-F, Buna-N, Neoprene, Viton or Nylon are Available
Straight Thru, Round Orifice (full opening available)
Chromium Plated or Polished Stainless Steel Ball

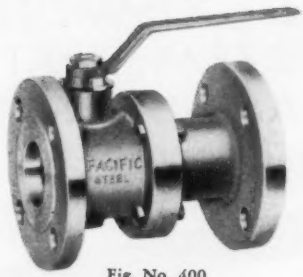


Fig. No. 400
Flanged Ends
150 lb. Series
Sizes – ½" thru 2"

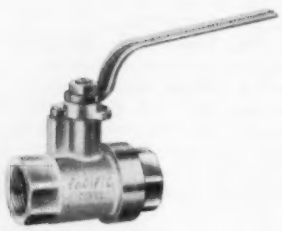


Fig. No. 225
Screwed Ends
Up to 1000 Lbs.
Sizes – ¼" thru 2"

Pacific Ball Valves are designed with but one purpose...*to outperform all other ball valves!* The criterion for each design decision was *performance.* Pacific's twenty-five years' experience manufacturing and rebuilding valves of all types, plus leadership in the number of types of valves accepted for the military nuclear and missile programs is your assurance of Pacific's valve "Know-How."

Pacific offers a wide range of *standard* Ball Valve materials: Cast Iron; Ductile Iron; Carbon Steel; CF8, CF8M & Alloy 20 Stainless Steels; and Monel. The *standard* ball seal materials are: Buna-N, Neoprene, Viton, Teflon, Kel-F and Nylon.

Pacific offers a complete line of valve actuators including its exclusive "PneuRotor"©, a pneumatic rotary operator mounted directly on the valve.

Pacific offers a specially designed line of "Fire-Safe" Ball Valves for applications where the maximum protection is necessary in the event of fire.

Pacific offers a line of Hi-Pressure Ball Valves, ⅛" through 1", for gas or air pressures up to 6000 p.s.i.

Sales Offices in most principal cities. Complete warehouse facilities at Long Beach, California; Emeryville, California; Houston, Texas; Woodbury, New Jersey and Broadview, Illinois.

NEW 64 PAGE BALL VALVE CATALOG

PACIFIC VALVES, INC.

3201 WALNUT AVE. LONG BEACH, CALIF.

Men . . .

of such petroleum products as oils, greases, and asphalts. He joined the laboratory staff in 1929, after graduating in chemical engineering from Armour Institute of Technology.

C. H. Marshall has been promoted to division engineer in the Cracking and Light Ends Division, Humble Oil & Refining Co.'s Baytown, Texas, refinery. He heads the Technical Department of that division. Marshall holds a B.S. degree in chemical engineering from Louisiana Polytechnic Institute.

Marshall

Robert E. Lenz, St. Louis, has been appointed director of engineering of Monsanto Chemical Co.'s Chocolate Bayou, Texas, project. Lenz was formerly assistant director of engineering of Monsanto's Research & Engineering Division, St. Louis. **Joseph Cresce,** St. Louis, has been appointed director of manufacturing at the project. He was formerly in charge of production for Monsanto Chemicals, Ltd., London, England.

J. R. Parten, director of The Pure Oil Co. and former president of Woodley Petroleum Co., has been named consultant on oil and gas matters by Interior Secretary Udall.

Paul Rand Dixon has been appointed chairman of the Federal Trade Commission by President Kennedy. Dixon was chief counsel to Senator Kefauver's antitrust subcommittee.

Dr. Harry E. O'Connell has been appointed project development manager, Tennessee Gas Transmission Co. Dr. O'Connell will handle expansion plans and diversification in the field of hydrocarbons utilization and petrochemicals. He obtained his Ph.D. degree in chemical engineering at the University of Michigan in 1941.

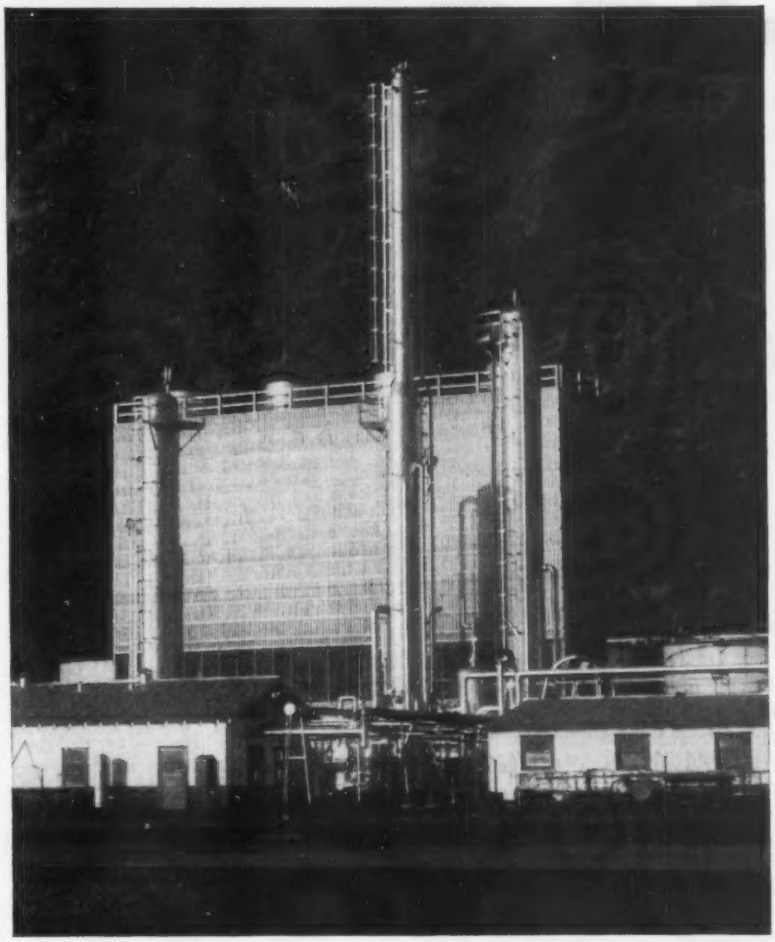
Henry L. Brown has been appointed director of public relations for National Distillers and Chemical Corp. Brown, formerly a vice president of Doremus & Co., advertising and public relations agency, had worked on the National Distillers public relations account at Doremus for the past 12 years.

Robert S. Barnes, Jr., has been named section leader, Research and Development Department, American Oil Co., Whiting, Ind. He will head research on greases and industrial lubricants. Such

new from Calgon . . .

HAGACIDES

a complete line of high toxicity biocides



Designed specifically for cooling water treatment, Hagacides provide a complete line of biocides that are highly effective. They may be used either by themselves, or as a supplement to other types of treatment.

Hagacides are effective against algae, slime, iron and sulphate reducing bacteria, and the complete spectrum of biological agents that impede cooling water operations. Hagacides are compatible with other water treatment chemicals; they are stable and are highly resistant to temperature extremes.

Easy to handle and feed, all Hagacides are completely safe for cooling tower wood. They are non-volatile, non-oxidizing and contain no corrosive metals. They penetrate and loosen debris which harbors microorganisms, and adhere to surfaces for a long lasting kill.

Hagacide biocides have proven themselves effective in situations where other biocides have failed. For more information, write:

CALGON COMPANY

HAGAN CENTER, PITTSBURGH 30, PA.

DIVISION OF **HAGAN** CHEMICALS & CONTROLS, INC.

For more data on advertised products, use Readers' Service Cards, last page.

1 or 126

READINGS AT THE FLICK OF A SWITCH WITH THE L&N MODEL D INDICATOR

Check any critical temperature accurately in a matter of seconds with this versatile Speedomax® G instrument. Supplied with toggle switches for up to 126 points; push-button switches for 24 or 48 points.

Other features include:

Scale—*Drum-type with a calibrated length of 25½ inches.*

Readability—*Up to 300 calibrated divisions.*

Deadband Rating—*0.15% of range, at any point on the scale.*

Accuracy Rating—*±0.3% of range.*

Span Step-Response-Time Rating—*4.5 seconds, for successive indications separated by full-scale span; 2.5 seconds, for half-scale.*

Power Supply—*Operates on 120 volts, 60 or 50 cycles.*

For more detailed information, ask for Data Sheet ND46-33(23). Write Leeds & Northrup Company, 4923 Stenton Avenue, Philadelphia 44, Pa., or check with your nearby L&N Field Office.

LEEDS & NORTHRUP
Instruments — Automatic Controls • Furnaces

Men . . .

research includes both finding out more about the properties of lubricants and seeking new ones to meet exacting military and civilian needs. Dr. Barnes obtained his bachelor's degree in chemistry at Massachusetts Institute of Technology and his doctorate in the same field at Harvard University.

Daniel L. Hussey, deputy manager of the Cologne, Germany, Esso refinery has been named government relations representative for New Jersey by Esso Standard, division of Humble Oil & Refining Co. While on loan from Esso Standard in 1954 and 1955, Hussey headed the team of experts from several countries which returned the huge Abadan refinery in Iran to production. It had been shut down for three years following Iran's nationalization of its oil industry. Hussey later became general manager at Abadan and director of Iranian Oil Refining Co. He will be at the Bayway refinery in Linden, N. J., in his new post.

Hussey

John O. Logan has been appointed general manager, Chemicals Division, Olin Mathieson Chemical Corp. A corporate vice president, Logan succeeds the late **Edward Block** as manager of the largest of Olin Mathieson's six operating divisions. He formerly was associate general manager. Headquarters of the Chemicals Division is in Baltimore.

Logan

Paul D. Meek has been appointed manager of Cosden Petroleum Co.'s Chemical Department. Meek, who has been with Cosden since 1955, will work in chemical sales, research and control.

H. W. McCobb has been named regional coordinator for operations, Standard Oil Co. (New Jersey), in Asia, Australasia and part of Africa. McCobb was formerly a vice president and director, Standard-Vacuum Oil Co.

B. F. Stradley has been elected financial vice president, Phillips Petroleum Co. He is also a director and member of the executive committee.

R. E. Kreider has been appointed manager of Mobil Chemical Co.'s Development Division. From 1940 until 1954 Kreider was with Esso Standard Oil

P.F.I.
THE PIPE FABRICATION INSTITUTE

These Members have participated in research and the development of advanced pipe fabrication methods . . .

CINCINNATI, OHIO
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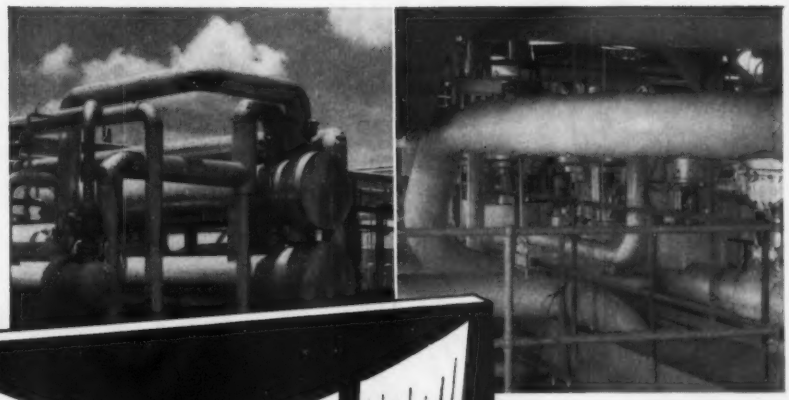
CONSULT A PIPE FABRICATION INSTITUTE MEMBER FOR YOUR PIPE FABRICATION NEEDS



P.F.I.

THE PIPE FABRICATION INSTITUTE

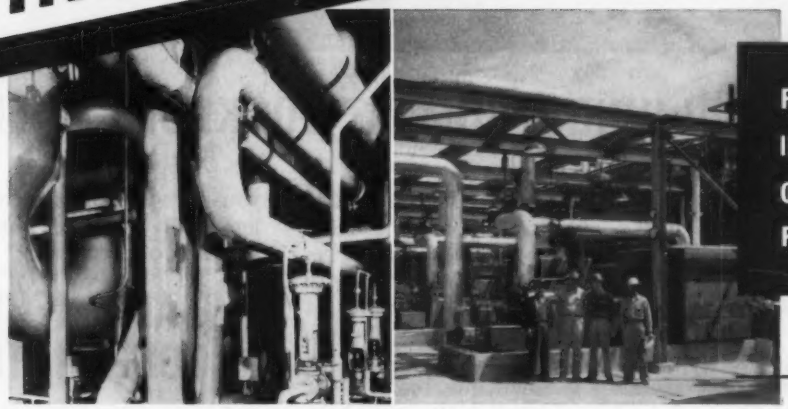
YOUR MOST DEPENDABLE SOURCES FOR MEETING EVERY EXACTING PIPE FABRICATING SPECIFICATION

When you use the services of any one of the 17 pipe fabricating specialists, listed on the opposite page, you secure many exclusive advantages only possible from the membership of P.F.I.

Only this group individually can offer the most comprehensive, correlated experience covering the most advanced methods of pipe frabrication techniques.

The technical and engineering committee groups of P.F.I., through their publications, have pioneered and established the highest standards for pipe especially in the area of high pressure and high temperature applications.

All reasons why . . . your piping needs are best served by members of P.F.I. A list of PFI Standards will be sent you on request so you can select the publication most useful for your needs.



PIPE FABRICATION INSTITUTE
ONE GATEWAY CENTER
PITTSBURGH, PA.

See Membership List on opposite page . . .

For more data on advertised products, use Readers' Service Cards, last page.

Texaco's Ljungstrom Air Preheater is being installed to boost the output of an existing still. This Ljungstrom has 5800 sq ft of heat exchange surface, will preheat incoming air from 50°F to 754°F. The still is the first step in processing crude oil for production of fuels and petrochemicals.

TEXACO INSTALLS LJUNGSTROM® AT LOCKPORT REFINERY

Ljungstrom Air Preheater cuts fuel consumption, boosts still capacity at Texaco's Lockport, Ill., refinery

Ljungstrom cuts fuel consumption. Since placed onstream last year, Texaco's Ljungstrom heat exchanger has been recovering over 700°F from the exhaust of the crude still, and putting this waste heat back into the combustion air.

Ljungstrom boosts still capacity. Preheated combustion air mixes more readily with the fuel, makes it burn more completely, with less slag and fewer deposits. This means less downtime, too.

For more information that will help you solve your heat recovery problem, call or write The Air Preheater Corporation.

THE AIR PREHEATER CORPORATION

60 East 42nd Street, New York 17, N. Y.

Men . . .

Co.'s refinery at Linden, N. J., where he became head of the Economics and Design Division in 1953. In 1954 he joined the secretary's office of Standard Oil Co. (New Jersey), and in 1956 he was appointed petrochemical coordinator of Standard-Vacuum Oil Co.

Edwin M. Haun has been appointed area development manager for the Asia-Pacific area of Monsanto Chemical Co.'s Overseas Division at St. Louis, after serving in the same capacity for projects without geographical limits.

Robert L. Norman has accepted a position as research engineer in process and plant design, Richmond Laboratory, California Research Corp. **Dr. Arnulf Vollmar** has become a research chemist in chemicals exploratory research, Richmond Laboratory.

Robert N. Simonsen, consultant, waste disposal and air pollution for The Standard Oil Company (Ohio), has been named chairman of the Oil Refining Industry Action Committee of the Ohio River Valley Water Sanitation Commission. Simonsen is in charge of coordinating Standard-Ohio's current and long-range program of pollution control work for both air and water. Previously, he had been secretary of the Oil Refining Industry Action Committee.

Simonsen

Dr. Hans Schindler has been elected a vice president of Sonneborn Chemical and Refining Corp. Previous to his promotion, Dr. Schindler was production manager of the Sonneborn oil refinery at Petrolia, Pa. He joined Sonneborn in 1946 as a senior research chemist.

Dr. Leo J. Peters has been named vice president and general administrator, Gulf Research & Development Corp., Harmarville, Pa. Peters was vice president and associate director of the firm.

— Deaths —

Ova Glenn Jackson, 65, recently retired head of the Purchasing Department, American Petrofina, Inc.'s, El Dorado refinery, died unexpectedly at his home in El Dorado, Kan., January 23.

Ernest Utterback, who retired from Socony Mobil Oil Co., Inc., last April after 27 years of service, died December 29 in La Mesa, Calif. He had been manager of the Design Division, Engineering Department.

Announcing!

A New Shaft Seal For Extremely Corrosive Service

TYPE 20

Made of DuPont Teflon

A new shaft seal to handle the most corrosive service conditions has been recently added to the John Crane line. Here's a seal that will stand up under all conditions of acids and salts, oxidizing agents and organic compounds.

It is so designed that all parts that normally contact the fluid are made of chemically-inert DuPont Teflon. Also, for this same reason it can be operated over wide temperature range up to 250° F.

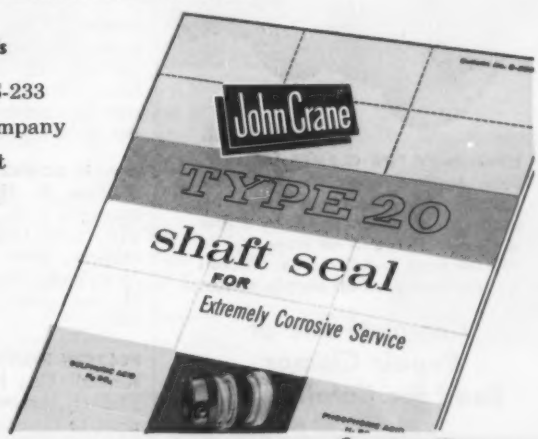
Mechanically, its bellows type construction readily adapts it for use in all non-abrasive slurry applications. It also compensates for extreme shaft run out.

Available in single face construction for internal or external mounting, double face for internal mounting.

Full range of shaft sizes from ⅜" to 3".

Get Complete Details

Request Bulletin S-233
Crane Packing Company
6420 Oakton Street
Morton Grove, Ill.
(Chicago Suburb)
In Canada:
Crane Packing Company, Ltd.
Hamilton, Ont.



John Crane
MECHANICAL PACKINGS
SHAFT SEALS
TEFLON PRODUCTS
LAPPING MACHINES
THREAD COMPOUNDS
CRANE PACKING COMPANY

For more data on advertised products, use Readers' Service Cards, last page.

SKINNER-SEAL
PIPE JOINT CLAMP STOPS LEAKS
at joint where pipe is screwed into fitting

SKINNER-SEAL
PIPE JOINT CLAMP stops leaks at joints where pipe is screwed into fitting. Any temperature—any pressure up to 2,000 pounds. Saves the cost of tearing out and renewing leaky fittings. Prevents shutdowns. In stock at most oil supply stores.

SKINNER-SEAL
EMERGENCY PIPE CLAMPS for safe, sure, lasting repair of splits and rust holes in pipe. No pressure too high. Anyone can apply in a few moments. Made in all sizes, ½" to 12" for steel and C.I. pipe. Stocked by practically all oil supply stores.

Complete line of Repair Clamps. Send for Catalog 54!

M. B. SKINNER CO.
SOUTH BEND 21, INDIANA

Suppliers Notes...

CONTINENTAL-EMSCO CO. has elected **C. L. Vickers** vice president of finance. He succeeds **D. M. Bailey,** who has joined Southern Union Gas Co. as executive vice president. **Will D. Crowell** has been appointed treasurer and credit manager; **Herbert P. Dawkins** becomes assistant treasurer and assistant credit manager; and **John F. Wagenhauser** has been named general counsel.

Vickers

Crowell

Wagenhauser

Dawkins

WORTHINGTON CORP.'s Annin Co. Division has appointed **Ross D. Randall** manager of engineering. He will head the division's 32-man engineering staff engaged in product design and development of pneumatic-hydraulic and electro-hydraulic control valves and shut-off valves.

CRUCIBLE STEEL CO. OF AMERICA has named **W. B. Downes** to handle executive customer relations for the Stainless Steel Division. Downes will spend his time in customer service covering stainless steels and high temperature alloys.

F & M SCIENTIFIC CORP. has appointed **William S. Hoover, Jr.,** district sales manager, New Castle, Del. His territory will cover Connecticut, Maine, Massachusetts, New Hampshire, New Jersey, New York, Rhode Island and Vermont. He was previously with W. H. Curtin Co.

POLYKEN PROTECTIVE COATINGS DIVISION, Kendall Co., is assigning **William J. Flaherty,** presently eastern regional manager, to Houston manager. He will headquarter in Houston, although his assignment is national in scope.

INLAND STEEL CONTAINER CO., pail and drum manufacturing division of Inland Steel Co., has elected **Duane R. Borst** treasurer. Borst was previously assistant comptroller of Joseph T. Ryerson & Son, Inland's steel merchandising subsidiary.

SERVICIO TECNICO DE POZOS "OTIS" C.A. has appointed **Harold Watson** district manager in the Venezuelan branch. Servicio Tecnico de Pozos is part of Otis Engineering Corp.

ACHESON INDUSTRIES, INC., has elected **Howard Acheson, Jr.,** general manager of the Acheson Dispersed Pigments Co. plant in Dunkinfield, England. Acheson has been production engineering manager of the company's plant in Philadelphia.

BORG-WARNER CORP. has appointed **Robert W. Halberg** associate director, Automotive Department, Roy C. Ingersoll Research Center. Halberg has been with Borg-Warner since 1947, beginning as a project engineer in the central office on special assignments.

CAMBRIDGE WIRE CLOTH CO. has elected **Harold E. Pink** vice president. Pink will help coordinate and advance plans being made to further develop and expand the company's operators in the United States, Canada and Mexico. He has been with the firm 27 years.

ROCKWELL-STANDARD CORP. has appointed **Thomas K. Brunner** sales manager of the Grating Division, Gary, Ind. Brunner has been with Rockwell-Standard and a predecessor company, Standard Steel Spring Co., since 1947.

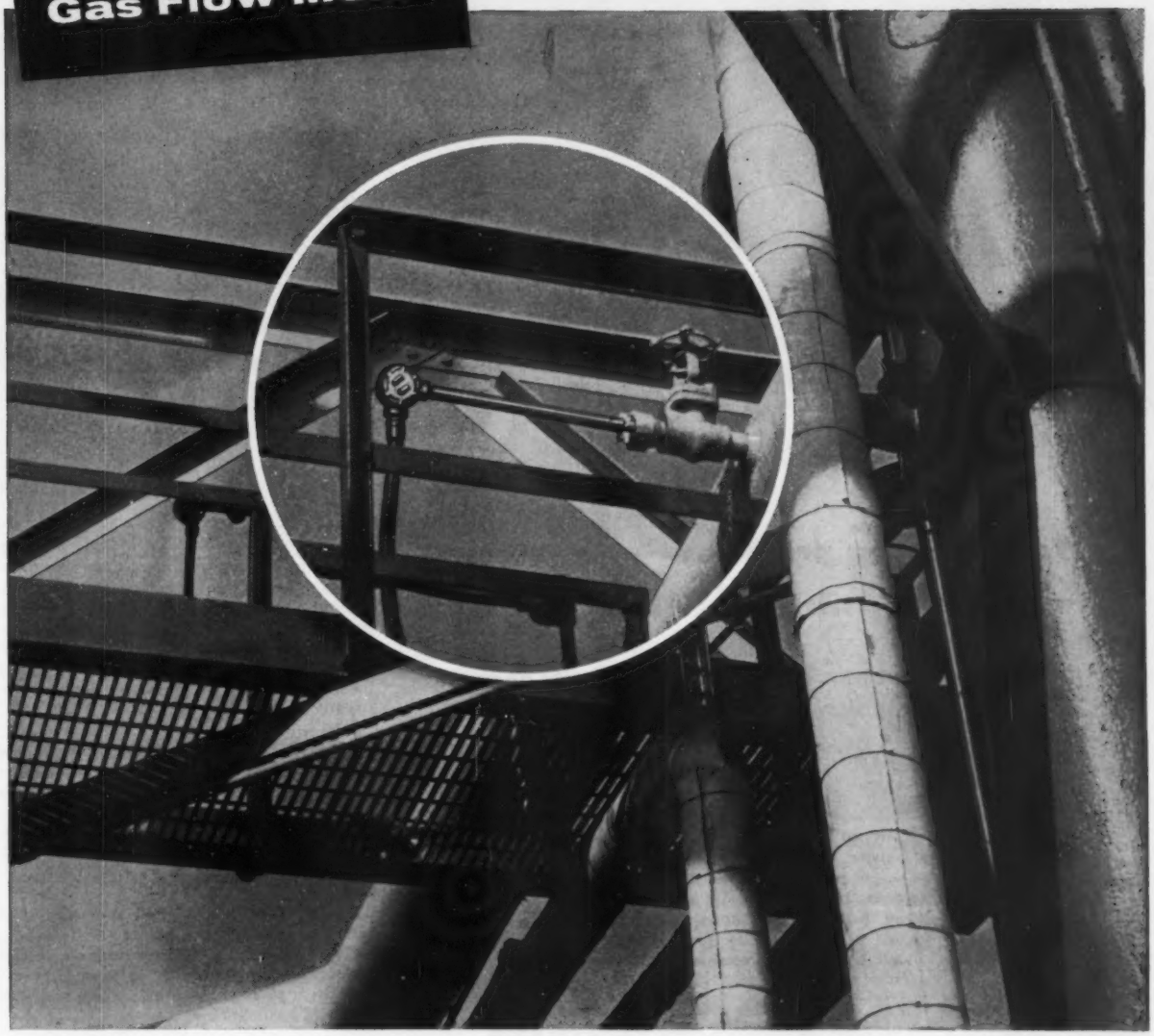
CRANE PACKING CO. has elected **Carlton N. Chandler** vice president of finance. Formerly secretary and treasurer, he will continue being secretary. Chandler is also treasurer of the firm's Canadian subsidiary, Crane Packing Co., Ltd. He has been with Crane since 1944. **Glenn Moore** has been named treasurer. He was previously controller for the National Gas Cylinder Division, Chemtron Corp.

Chandler

Moore

PEABODY ENGINEERING CORP., New York, has named **John R. Woolaver** manager of the Philadelphia area office. Peabody is a designer and manufacturer of fuel burning equipment, remote burner systems

"Anemotherm" Gas Flow Meter cuts flare stack losses



Are thousands of dollars going up your flare stack? You can substantially reduce these flaring losses with the "Anemotherm" *Probe-Type* Gas Flow Meter. This electronic, stainless steel instrument accurately measures the gas flow in the flare stack and the lines leading into it from various units. By determining flow rates and points of loss, refineries report savings of thousands of dollars per day.

Investigate the application of the "Anemotherm" Gas Flow Meter's wide range measurement, response to low velocities and available control functions in the following fields:

- *controlling atmospheric pollution*
- *increasing combustion efficiency in boilers, furnaces and heat treating equipment*
- *measuring the flow of air in catalytic cracking units*
- *metering the rate of flow in gas transmission lines.*

Put the money-saving accuracy and efficiency of the "Anemotherm" Gas Flow Meter to work for you. *Send for 8-page Technical Bulletin 5100 giving complete engineering data.*

ANEMOSTAT®

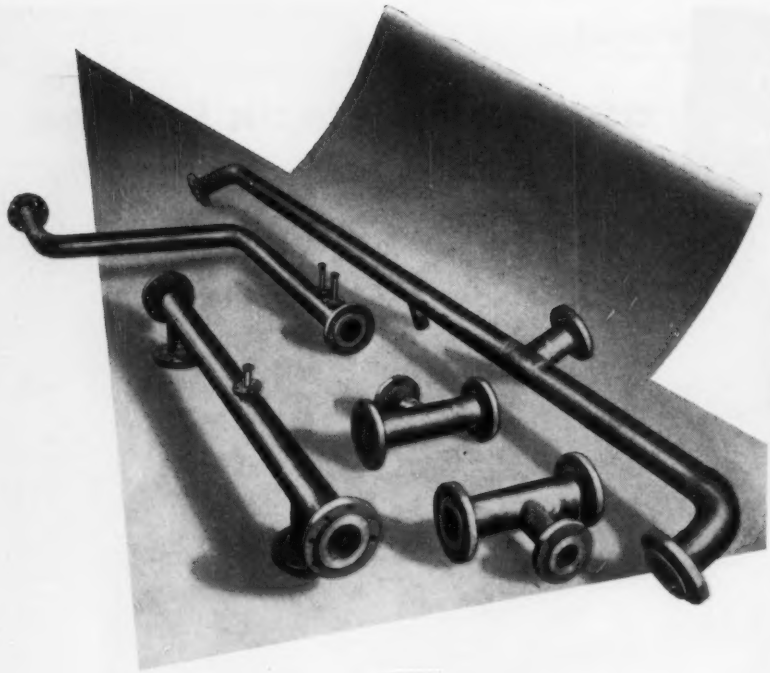
ANEMOSTAT CORPORATION OF AMERICA

10 East 39th Street, New York 16, N. Y.

Representatives in Principal Cities

AC 1378

For more data on advertised products, use Readers' Service Cards, last page.



Tough piping problems made easier with AMPCO* PIPE

. . . the pipe that resists corrosion and velocity damage, withstands mechanical abuse

Put Ampco Pipe on your tough, liquid-handling jobs, and, mister, you've got something. First of all you've got pipe that's easier and less costly to install. It stands up under wrenches and hammers without thread distortion and subsequent leakage. It is readily welded with shielded arc procedures. "On-the-job" changes and maintenance may be done by the average weldor.

Pipe made from this unique aluminum-bronze alloy is hard, yet it's unusually tough — gives you Brinell hardnesses of 150 and tensiles up to 70,000 psi. It has high strength-to-weight ratios.

But here's the best part of the story. It is highly resistant to many acids and caustics. It has high velocity tolerance—permits flow rates up to 18-20 fps. It withstands the action of abrasive solids in suspension and resists cavitation-pitting. It combines the advantages of many different pipe materials without their drawbacks.

What's more, you can get Ampco Pipe in all standard sizes, many from stock. Fittings are also available to 3600 psi and flanges to 5000 psi. Write us now for full information.

AMPCO

Sole Producer of Genuine Ampco Metal

AMPCO METAL, INC.

Dept. 381-C, Milwaukee 1, Wis.

West Coast Plant
Huntington Park, Calif.
Southwest Plant
Garland
(Dallas County), Texas

*Reg. U. S. Pat. Off.

PR-10C

Suppliers . . .

controls, direct-fired air heater furnaces, gas cleaning equipment and inert gas systems.

HARBISON-WALKER REFRACTORIES CO. has elected **Earl A. Garber** chairman of the board, and **A. Brenet Wilson** president. Garber, as chairman of the board, will

Garber

Wilson

continue to be the chief executive officer of the company. Wilson, a metallurgical engineer, joined Harbison-Walker in 1934.

LAYNE ASSOCIATES was recently formed in Memphis, Tenn., to promote development and conservation of water supplies and to provide technical information through research in the field of water. The firm will seek newer and better methods for finding and treating ground water in ample supply and to keep up with the ever increasing demand for water required by industry.

AIR REDUCTION SALES CO. has named **N. F. Moody** eastern regional sales manager. Moody's territory includes New Jersey, Massachusetts, New York, Pennsylvania and Ohio. Moody succeeds **A. S. Blodget,** who is vice president, midwestern region.

DATEX CORP. has opened a district sales and service office to serve the Northern California area in Monrovia, Calif. **George Cline,** formerly sales engineer in the firm's western regional office, has been named manager.

PACIFIC PUMPS, INC., a division of Dresser Industries, Inc., has appointed **John H. (Jack) Young** supervisor of sales for steam turbopumps and turbines. He joined Pacific Pumps in 1958.

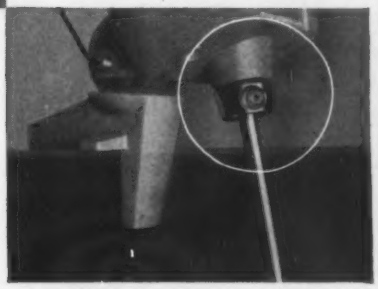
TEMPTRON, INC., Reseda, Calif., has named **William Draganchuk** product manager. Temptron specializes in the field of temperature measurement. Draganchuk was previously with General Cable Co., Thermo Electric Co., and Tech Wire & Cable Co.

CONSOLIDATED ELECTRODYNAMICS CORP., Data Recorders Division, has named **Herbert I. Chambers** director of engineering. Chambers was formerly associate director of CEC's DataTape Division. **John F. Moffat, Jr.,** has been appointed manager of the Datagraph

SHOCK OVERLOADS can't damage the mixer drive. In gear-drive models, GripSpring assembly between gear and drive shaft lets gear slip if overloaded more than 50%. It's a safety feature you never could get before in a portable mixer.

NEW MIXER

Get set to topple some traditions in fluid-mixing ease and economy



SAVE COST of a corrosion-resistant alloy with this shaft chuck. It's way up out of the tank—always above liquid level. It's simple, quick-acting. Tighten one screw, and shaft is locked—can't come loose unless you want it to.

You won't have to lubricate it for five years.

Overloads can't hurt the gear drive.

It comes with a chemical plant motor as *standard,* at no extra cost.

You don't need three hands to remove the shaft.

And it mixes fluids like no portable mixer you've ever seen. Delivers up to 45% more fluid flow in gear-drive models . . . higher impeller head in direct-drive models. Actually lets you handle many mixing jobs with a *smaller* mixer drawing *less power.*

That's just a sampling of the new LIGHTNIN Portable Mixer. It has been tested under every conceivable condition of use and load. It's ready—in sizes from ⅛ to 3 hp, gear drive or direct drive. And the price is right.

Your LIGHTNIN Mixer representative will be glad to show you why you can use it to mix fluids better—and at lower cost—than ever before. You'll find him listed in Thomas' Register and in the yellow pages of your telephone directory. Call him today. Or write us for descriptive Bulletin B-520.

NO MYSTERY about the right mixer angle for best mixing. Vertical and horizontal indexing makes it a snap to describe the right setting so everybody understands.

IN FIXED MOUNTINGS, TOO. Get the same all-new advantages in permanent-mounting LIGHTNIN Mixers for open and closed tanks. A complete line, sizes from ¼ to 3 hp. For details on these, send for Bulletin B-521.

Lightnin® Mixers

MIXCO fluid mixing specialists

MIXING EQUIPMENT Co., Inc., 164-c Mt. Read Blvd., Rochester 3, N.Y.

In Canada: Greey Mixing Equipment, Ltd., 100 Miranda Avenue, Toronto 19, Ont.

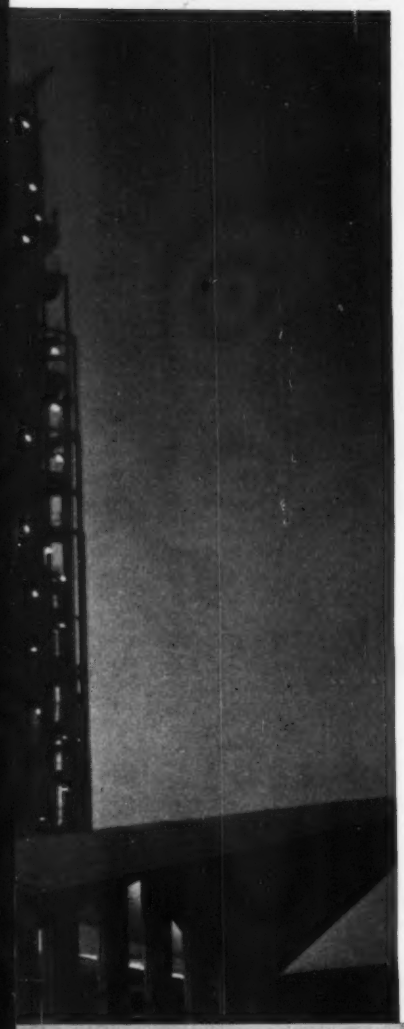
In Europe: Lightnin Mixers, Ltd., Poynton, Cheshire, England

Foxboro pneumatic control huge Canadian

Photography by John K. Harris

THREE FOXBORO CONTROL PANELS for Imperial's Chemical Products Cracking Unit are housed in this unique hexagonally-shaped control room. Panels, which are arranged in a star-shaped pattern, contain 178 Consotrol recorders and controllers. Panels were built by The Foxboro Company, Limited, Montreal.

installed at Refinery and Petrochemical Plant



Imperial Oil's giant Sarnia Plant counts on Foxboro Consotrol* instruments for accurate, dependable control

From its star-shaped control room to its towering columns, they've used the most advanced refining techniques at Imperial Oil's 94,000 barrel-per-day refinery at Sarnia, Ontario.

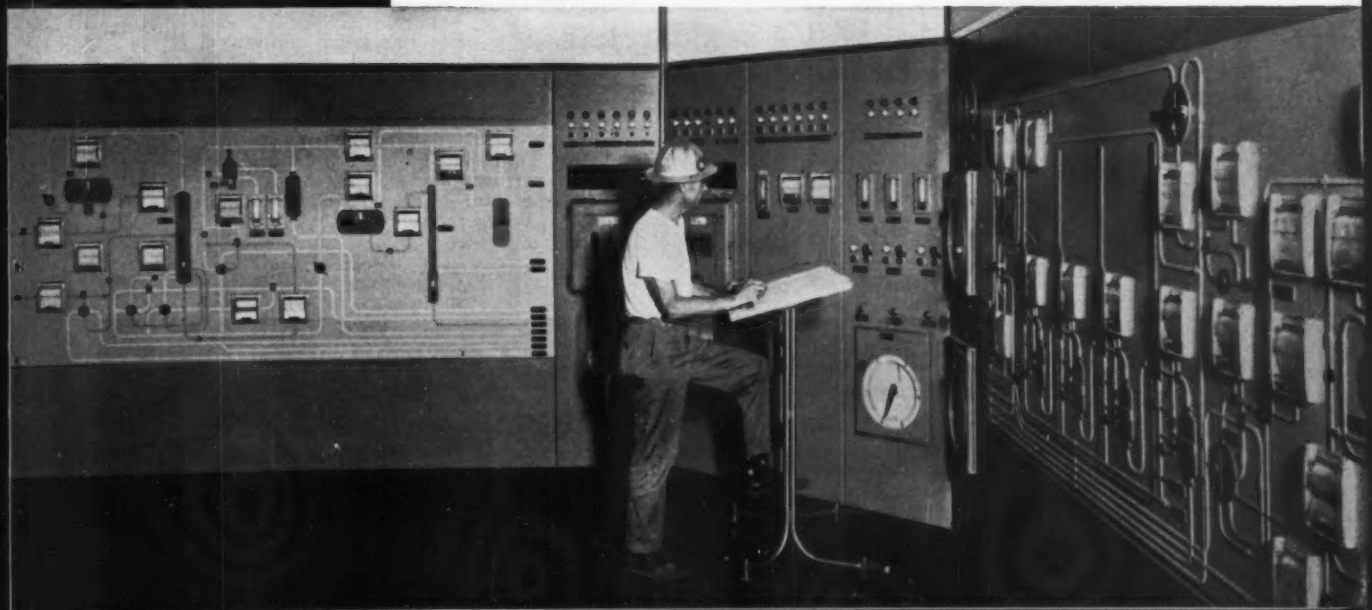
Little wonder that accurate, dependable, low-maintenance Foxboro Consotrol instruments were installed. For example, clay treating, cracking and fractionation, ethylene recovery, butadiene extraction, refrigeration, light ends, Hydrofining, Powerforming, debutanizing, detergent alkylation, and production of Naptha Specialties — all operate under Foxboro control.

Actually, you'll find Foxboro small-case pneumatic consotrols serving leading refineries wherever reliable instrument performance is a must. If you're not familiar with the Consotrol story, ask your nearby Foxboro Field Engineer for full details. Or write for Bulletin 13-18. The Foxboro Company, 743 Neponset Avenue, Foxboro, Massachusetts.

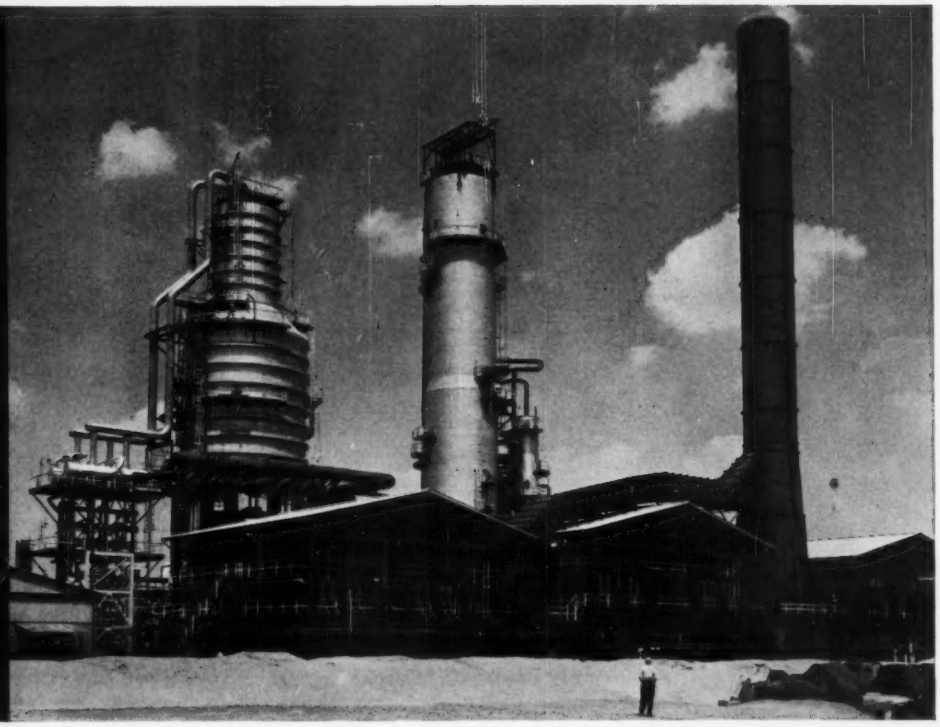
Reg. U. S. Pat. Off.

FOXBORO
REG. U. S. PAT. OFF.

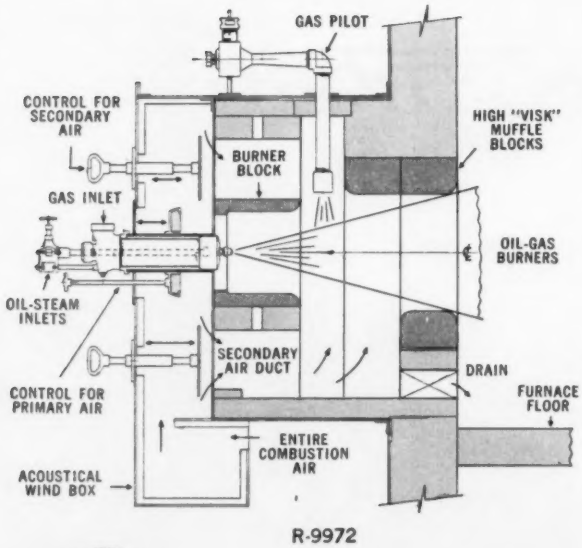
THESE FOXBORO CONSOTROL PANELS are installed in the Powerformer Unit Control Room.



NATIONAL AIROIL TANDEM COMBUSTION UNITS . . .



Help Improve Performance of Nation's Largest Crude Still



R-9972

The nation's largest crude still—140,000 barrels per day rated capacity with ample reserve—is equipped with National Airoil improved Combination Oil and Gas Tandem Combustion Units . . . for *better* service and *improved* performance.

The oil fuel is high viscosity uncut vacuum tower bottoms, supplied to the burner at high temperature. The gas is refinery type at only medium pressure.

The burner design details emphasize a maximum of heat transfer by flame radiation with a high turn-down ratio.

Combustion noise has been minimized, on both primary and secondary air, by means of the acoustical wind-box which also serves as a "wind break."

Perhaps a National Airoil Combination Oil and Gas Tandem Combustion Unit can help improve performance at your installation. A discussion of your problem entails no obligation whatever. Write today.

NATIONAL AIROIL BURNER

Established 1912
Incorporated 1917

NATIONAL AIROIL BURNER COMPANY, INC.
1284 E. Sedgley Avenue • Philadelphia 34, Pa., U.S.A.
Industrial Oil Burners, Gas Burners and Combustion Equipment

For more data on advertised products, use Readers' Service Cards, last page.

Engineering Department, **Fred F. Grant** has been made manager of the Data-Tape Engineering Department, and **John J. Smith** becomes manager of the Custom Products Department.

KEROTEST MANUFACTURING CO. has elected **E. N. Wrenshall** vice president. Wrenshall has been with the company since 1946, first as director of purchases, then in 1958 appointed general manager.

OTIS ENGINEERING CORP., Dallas, has named **Carl O. Fleming** manager of manufacturing. He will direct the production, purchasing, and plant production departments. Fleming was formerly administrative assistant to the senior vice president. In this position, he was coordinator for the planning of Otis' $2-million plant and office complex presently under construction at Carrollton, Texas. He joined Otis in 1954, and was transferred to the Dallas offices as industrial engineer in 1955.

Fleming

EBASCO SERVICES, INC., has appointed **Larry J. Aubrecht** director of western regional operations for the Management Consulting Division. Aubrecht replaces **H. K. Breckenridge,** who has been assigned to Ebasco's New York headquarters.

HAGAN CHEMICALS & CONTROLS, INC., has named **Matthew Gould** director of chemical equipment development in the Chemical Research and Development Department. Gould will be concerned with chemical analyzers and chemical feed equipment.

P. D. BROWNE CO. has opened an Oklahoma office at 3216 East 21st St., Tulsa, to serve the entire state except for the extreme western part. P. D. Browne is a manufacturer representative for various Parker-Hannifin pneumatic and hydraulic products.

CAL-METAL PIPE CORP. OF LOUISIANA has appointed **Joe E. Byrd** sales representative for the Houston office. Byrd joined Cal-Metal at the beginning of this year after working for two other supply companies in Houston.

JONES & LAUGHLIN SUPPLY DIVISION has named **L. C. McKinney** assistant controller. McKinney joined Jones & Laughlin as systems supervisor in the Accounting Department in 1956.

PACIFIC VALVES, INC., has negotiated a trade and manufacturing agreement with Weir Valves, Ltd., Glasgow, Scotland,

BONDSTRAND®

THE "PROBLEM-SOLVER" PIPE

Bondstrand is no ordinary plastic pipe: Made of tension-wound glass filaments, impregnated with chemical-resistant resin—either epoxy or polyester—it is strong as steel . . . yet only one-eighth the weight.

THE PROBLEM	THE LOCATION	THE SOLUTION
Carbon black slurry destroyed schedule 40 steel pipe in 30 days	Synthetic Rubber Plant	Bondstrand installed 1959. No failure. Performance still rated excellent
Chlorine Dioxide water caused failure in stainless steel pipe	Paper Plant	Bondstrand installed 1958. Performance still rated excellent
10% Ferric Chloride solution destroyed ordinary steel or stainless	Sewage Treatment Plant	Bondstrand installed 1958. Performance still rated excellent
Salt water well injection at 1600 psi	Petroleum Production	Bondstrand installed 1958. No failure. Performance still rated excellent

Bondstrand's total installed cost can be actually competitive with ordinary carbon steel pipe. Write for bulletin containing physical and design data.

Amercoat® CORPORATION

132A

Dept. VO, 4809 Firestone Blvd.
South Gate, California

921 Pitner Ave. Evanston, Ill. | 360 Carnegie Ave. Kenilworth, N.J. | 111 Colgate Buffalo, N.Y. | 2404 Dennis St. Jacksonville, Fla. | 6530 Supply Row Houston, Tex.

For more data on advertised products, use Readers' Service Cards, last page.

ELLIOTT air magnetic tube expander drives

automatically controlled for fast, accurate tube rolling

Designed for faster, precision tube rolling, the standard model Elliott Air-Magnetic drive is setting new records for speed and accuracy. Some operators average 12 tubes per minute. Desired torque easily preset by rotating forward end of unit. No tools needed. Rolling stops when preset torque levels are reached. Includes trigger-controlled, explosion-proof air motor in single unit. Magnetic control, no springs. Balanced for easy handling. For tubes ¼ in. through 3 in. *Standard model* handles most jobs. *Heavy-duty* for higher torque.

ALSO Tube Expanders and Related Accessories

Elliott offers a complete line of tube expanders, with rotating, parallel, self-feeding rolls. Available in 4 types, ranging from ¼ in. to 3½ in. O.D. Also the Automatic Electric Control—an accurate torque-limiting device designed for tube expanding with any standard tapping motor.

WRITE for Bulletin Y-53

Elliott Tube Gage

Y1-2

ELLIOTT COMPANY

GENERAL OFFICES: JEANNETTE, PENNSYLVANIA

PLANTS AT: Jeannette and Ridgway, Pa.; Springfield, Ohio; Newark, N. J.

TURBINES · GENERATORS · MOTORS · COMPRESSORS · TURBOCHARGERS
DEAERATING HEATERS · EJECTORS · CONDENSERS · STRAINERS · TUBE CLEANERS

Suppliers . . .

whereby Weir Valves will have manufacturing and marketing rights to Pacific's entire line of valve products for the hydrocarbon processing industry.

PERFEX CORP. has promoted **George P. Karas** to assistant manager, Perfex Pak Division. Karas, an engineering graduate of Marquette University, joined Perfex in 1959 as a sales engineer.

ALCO PRODUCTS, INC., has elected **William A. Callison** to the board of directors. He is regional vice president at Chicago. Callison succeeds **George W. H. Allen,** who resigned from the board.

RAYBESTOS-MANHATTAN, INC., has appointed **S. R. Zimmerman, Jr.**, executive vice president. Zimmerman is a director and vice president of the corporation.

HILLS-McCANNA CO. has named **Richard F. Dauenhauer** manager, distributor sales. He will head the company's sales of ball valves and diaphragm valves through industrial distributors in the United States and Canada. Prior to joining Hills-McCanna last October, he was western sales manager for Ohio Injector Co.

COLEMAN INSTRUMENTS, INC., has appointed **Henry N. Staats** development director. Staats will be in charge of research, engineering and applications for Coleman, designers and manufacturers of instruments for industrial chemical analysis.

COOPER ALLOY CORP. has named **Gerald Lewis** vice president, marketing and engineering. Lewis will handle product design and development as well as marketing of products of the corporation's four manufacturing divisions. He was formerly director of product engineering for the company, a post be held since 1959. He joined the Vanton Pump and Equipment Corp. Division in 1955 as sales manager. Prior to this Lewis was chief engineer of the J. J. Ashton Co., New York.

Lewis

F & M SCIENTIFIC CORP. will build a research and production building near Avondale, Pa. Occupancy is expected in September 1961. F & M makes linear-programmed temperature gas chromatographs and other analytical instrumentation.

GENERAL BLOWER CO., Morton Grove, Ill., manufacturer of industrial fans and blowers, has named T. E. Byerly Co., Inc., Baltimore, sales representative. Ed

For more data on advertised products, use Readers' Service Cards, last page.

Five years later:

No repairs needed on regenerator's refractory concrete lining

When this regenerator chamber was opened at the Canton (Ohio) refinery of the Ashland Oil & Refining Company after five years of service, the refractory concrete lining was in excellent condition. No replacement was needed. The smooth, jointless surface of the concrete, made with LUMNITE calcium-aluminate cement, required only minor patching. It resisted abrasion by catalyst and the penetration of gases.

In other refinery equipment (heaters, vapor separators, transfer lines, cyclones, stacks, breechings, etc.) refractory concretes made with LUMNITE cement can be designed to meet every operating condition. For extra convenience and economy, castables containing LUMNITE cement are available from leading manufacturers of refractories. These are packaged mixtures, requiring just water and mixing. For more information, write Universal Atlas Cement, 100 Park Avenue, New York 17, N. Y.

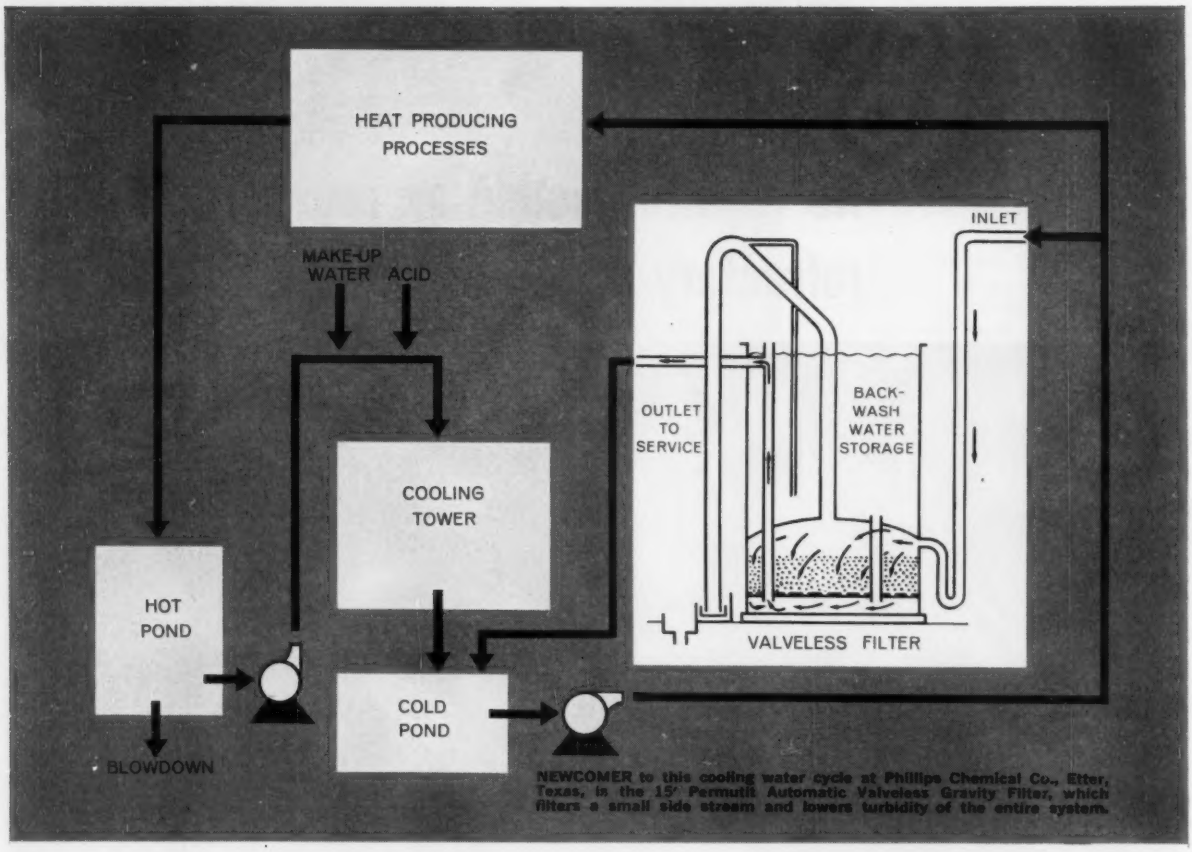
"USS," "Atlas," and "Lumnite" are registered trademarks

L-210

Universal Atlas Cement
Division of
United States Steel

Offices: Albany · Birmingham · Boston · Chicago · Dayton · Kansas City · Milwaukee · Minneapolis · New York · Philadelphia · Pittsburgh · St. Louis · Waco

FLUIDICS* AT WORK



NEWCOMER to this cooling water cycle at Phillips Chemical Co., Etter, Texas, is the 15′ Permutit Automatic Valveless Gravity Filter, which filters a small side stream and lowers turbidity of the entire system.

New way to shrink yearly maintenance costs—improve heat exchanger operation

Here is a new wrinkle in cooling-tower operation:

Side stream filtration. It can appreciably cut your yearly bill for cleaning fouled heat exchanger surfaces and condenser tubes.

Between the cooling-tower and the heat-exchange operation stands a newcomer to the system—a Permutit® Automatic Valveless Gravity Filter.

Its job is to clean up a small portion of the main cooling water stream, roughly 1% to 5%. By continuously filtering this small side stream the turbidity of all the cooling water is reduced and held to an acceptably low level.

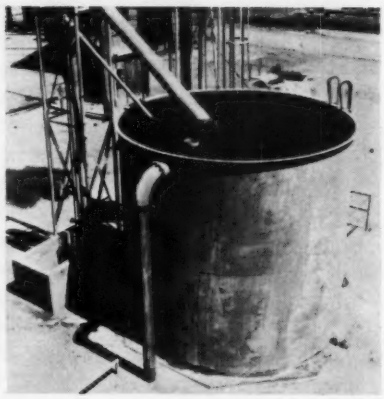
In the system shown here, suspended matter dropped from 2.0 ppm to 0.5 ppm in just one week, and continued to decrease thereafter.

Less turbidity in the cooling water means less fouling of heat exchange equipment. Less fouling, fewer cleanings, more efficient operation.

Costs nothing to operate: To sweeten your savings a little more, the Permutit Valveless Gravity Filter is automatic, in every sense of the word. It operates itself, backwashes itself. Has no moving parts, requires no attendant, no power, no extra pumps. The water used to wash serves as part of the system blow-off—at no extra cost.

Now in use: Proved in this new application, the Permutit Automatic Valveless Gravity Filter is already saving money for several companies.

All you need, to join them, is a little space near your cooling tower, and a Permutit Automatic Valveless Gravity Filter. For more facts, write: Permutit Division, 50 West 44th Street, New York 36, New York.



FILTER in use at Phillips Chemical Co. is entirely automatic. Shuts itself off when backwashing, puts itself back into operation when backwashing is completed.

PFAUDLER PERMUTIT INC.

A world-wide company with plants in Germany, Great Britain, Canada, Mexico, Japan, as well as the U.S.A.

*FLUIDICS is the Pfaudler Permutit program that integrates knowledge, equipment and experience in solving problems involving fluids.

For more data on advertised products, use Readers' Service Cards, last page.

Suppliers . . .

Byerly, head of the sales agency, is a mechanical engineering graduate of Cornell University. For the past seven years he has operated a sales group in chemical processing equipment.

COOPER-BESSEMER CORP. has appointed **David Salls** manager of gas industry sales. Prior to this appointment, Salls was manager of gas turbine sales. He will make his headquarters at Mount Vernon, Ohio. **William B. Boyum** has been named

Salls

Boyum

manager of gas turbine sales. Boyum was with Air Products, Inc., and Dynamic Research, Inc., before joining Cooper-Bessemer.

ATLAS POWDER CO. has appointed **William W. Hays** marketing manager, Chemicals Sales Department. Hays, who had been acting marketing manager since March 1960, joined the firm in 1946 as a salesman in what was then the Industrial Chemicals Department.

KAISER STEEL CORP. has appointed **B. E. Olsen** assistant manager of sheet and strip sales. Olsen will headquarter in the company's general sales offices, Kaiser Center, Oakland, Calif. He was formerly sales representative with central district sales for the firm.

CRUCIBLE STEEL CO. has named **J. W. Slattery** manager, distributor relations. He will handle coordinating and developing sales of products through distributor outlets.

CONTINENTAL-EMSCO CO. has appointed **Robert M. Erskine** assistant general manager of non-tubular sales. Erskine, former manager of subsurface equipment sales, joined Continental-Emsco in 1953 as a sales engineer.

SIMPSON ELECTRIC CO. has made **Charles R. Billman** vice president of manufacturing. He will be in charge of all manufacturing and associated operations in Simpson's six separate plants.

MINNEAPOLIS-HONEYWELL REGULATOR CO.'s industrial products group has appointed **Paul K. Webster** metals processing market manager with headquarters in Philadelphia. **Robert W. O'Reilly,** sales group supervisor in the Philadelphia

KAISER LO-ERODE®: HIGHEST RESISTANCE TO EROSION IN CYCLONES—TO 2400° F

Kaiser Lo-Erode high-purity, low-iron castable refractory is especially designed to resist the severe abrasive forces in refinery cyclones, lines, elbows, standpipes, and sugar-scoops.

It gives you the most effective, most economical abrasion resistance available in a refractory today.

In Lo-Erode, an extremely dense and hard aggregate is combined with a special binder. The result is superior strength and excellent erosion resistance within the service temperature range of catalytic units. Lo-Erode is ideal for use where highly abrasive particles or fluid solids are being handled at accelerated velocities.

For full details and installation procedures, call or write Kaiser Refractories & Chemicals Division, Kaiser Aluminum & Chemical Sales, Inc. (Canadian Subsidiary: Refractories Engineering & Supplies, Ltd.)

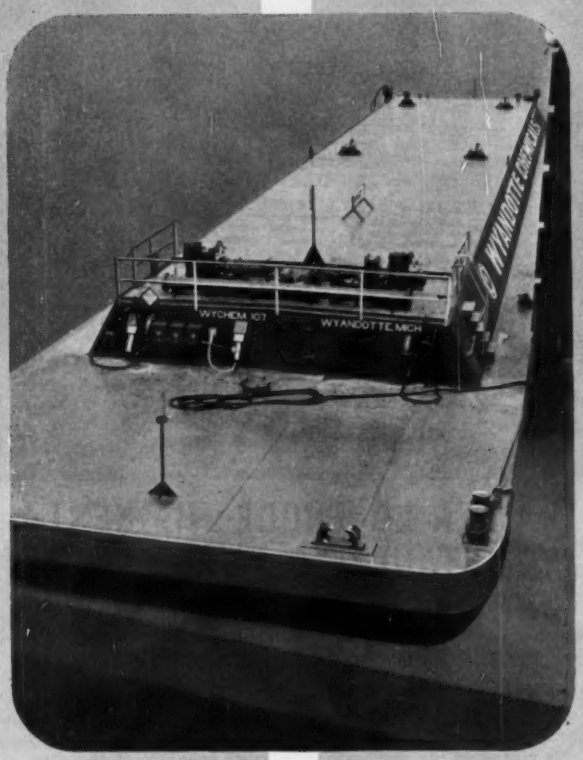
PITTSBURGH 22, PA. . 3 Gateway Center
MEXICO, MISSOURI . Mex-R-Co Building
OAKLAND 12, CALIF. . 300 Lakeside Drive

KAISER REFRACTORIES

See HONG KONG and MAVERICK every week, on the ABC-TV Network. Consult your local TV listing.

For more data on advertised products, use Readers' Service Cards, last page.

Caustic Soda ...a Wyandotte Key Chemical



Bargain by barge? When caustic by barge is a bargain, it could be a big one. That's why we look carefully into a customer's position before we ship . . . by barge, rail, or truck . . . from Geismar in the South, or from Wyandotte in the North. It's part of the service that makes Wyandotte caustic a Key Chemical in your operation. May we help you pinpoint your most economical position?

WYANDOTTE CHEMICALS

MICHIGAN ALKALI DIVISION, WYANDOTTE, MICHIGAN

Suppliers . . .

branch office, becomes branch industrial sales manager in Baltimore.

PYLE-NATIONAL CO. has promoted **John M. Crocker** to manager of fitting sales. Crocker, previously assistant manager, fitting sales, joined the firm in the Design Engineering Department in 1949.

BASTIAN-BLESSING CO. has elected **Lewis G. Blessing,** president since 1931, chairman of the board. **Allison L. Augur** has been promoted from executive vice president to president. **Lawrence N. Lucas** rises from vice president to executive vice president replacing Augur. Blessing was co-founder of the firm in 1908. Augur joined the company in 1923 as assistant sales manager of the Rego Valve Division. Lucas came to the firm in 1937.

Augur

PIPE LINE SERVICE CORP., a subsidiary of American Steel Foundries, Chicago, has started construction of a steel pipe coating and wrapping plant in Youngstown, Ohio.

GARDNER-DENVER CO. has moved into its new Chicago-area office at 2535 South 25th Avenue in Broadview. The new 9,800-square-foot building has 1,800 square feet of space available for parts.

CRANE CO.'s industrial products group has appointed **J. L. Huss** manager of customer distribution service. Huss has been with Crane Co. since 1950.

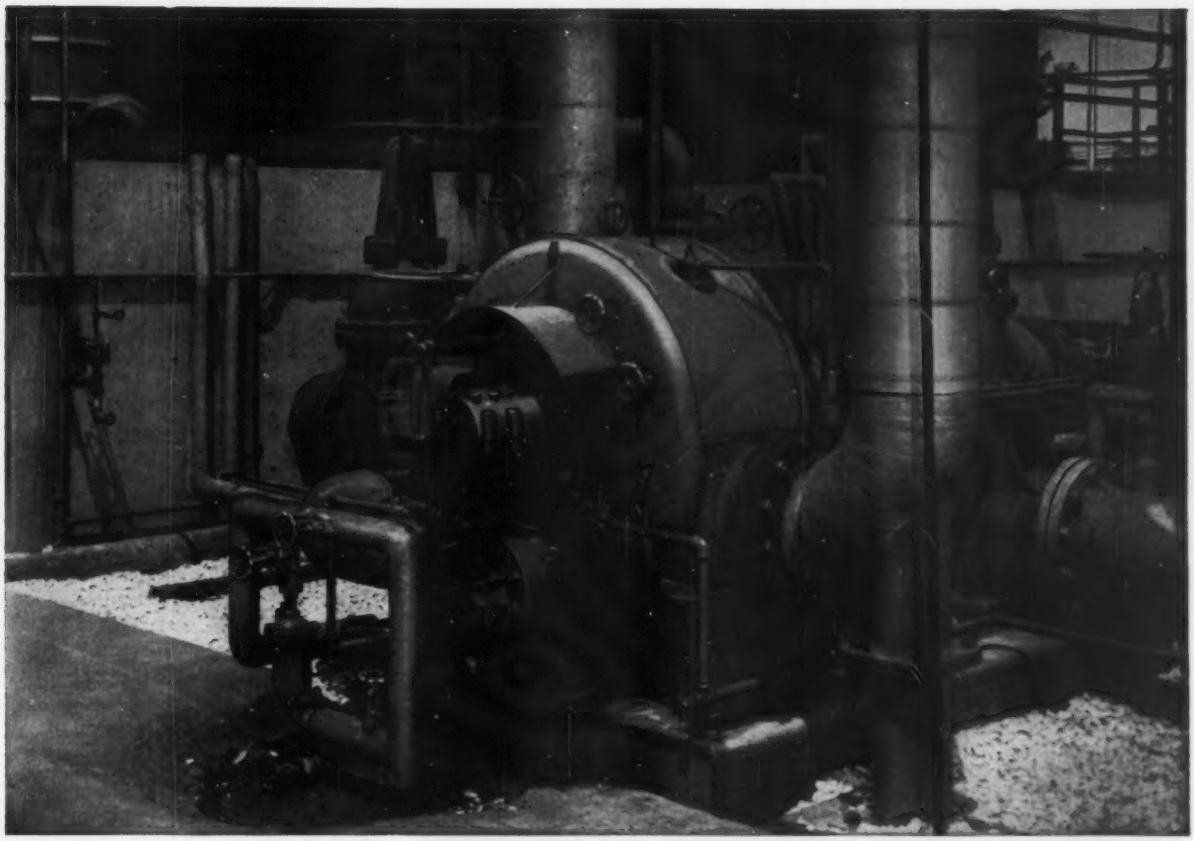
SMITH TOOL CO., Los Angeles, has changed its corporate name to Smith Industries International, Inc. Smith Tool Co. will continue as a division of Smith Industries, as well as the Bufnel Co., which manufactures a line of industrial grating products.

ROCKWELL MANUFACTURING CO.'s Meter & Valve Division has named **William W. Shade** district manager in the Kansas City, Mo., area. He was formerly a sales manager in the district. Shade joined Rockwell in 1950 as a market analyst.

COOPER-BESSEMER CORP. has promoted **James R. Craine** to assistant manager of the East-central sales district. Craine came to the company in 1952 as a sales engineer. He was made branch manager of the Mount Vernon sales office in 1958.

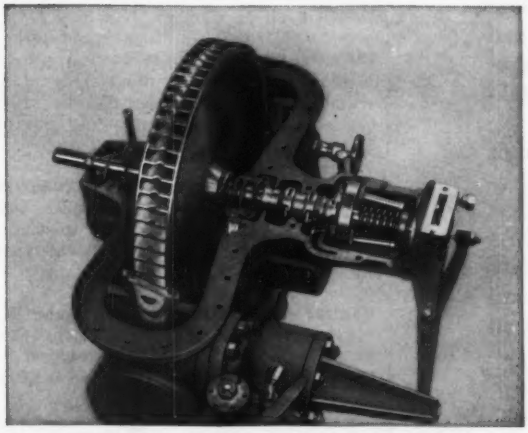
MORSE CHAIN CO. has named **Howard W. Bennett** market manager. Bennett has been with General Electric Co. for 31 years, and has been both sales manager and marketing manager for gearmotors

For more data on advertised products, use Readers' Service Cards, last page.



TERRY SOLID-WHEEL TURBINES

used exclusively at Baton Rouge plant of W.R.Grace & Co.



The upper photograph shows one of the 17 Terry turbines installed at the Baton Rouge, La., GREX high-density polyethylene plant of W. R. Grace & Co. Above, a typical Terry solid-wheel turbine with cover removed to show the wheel construction.

In purchasing equipment for their new 50,000,000-pound high-density polyethylene plant, W. R. Grace & Co. standardized, wherever possible, on a single source of supply for each type of equipment used. Consistent with this policy, Terry steam turbines were used exclusively throughout the utility and process sections of the plant.

A total of 17 turbines were placed in service for driving pumps and fans. These are all of the solid-wheel type, ranging in capacity from 50 to 240 HP.

Terry solid-wheel turbines are known for their long life and sure dependability under the most-trying operating conditions. They feature a single-piece wheel which is virtually indestructible.

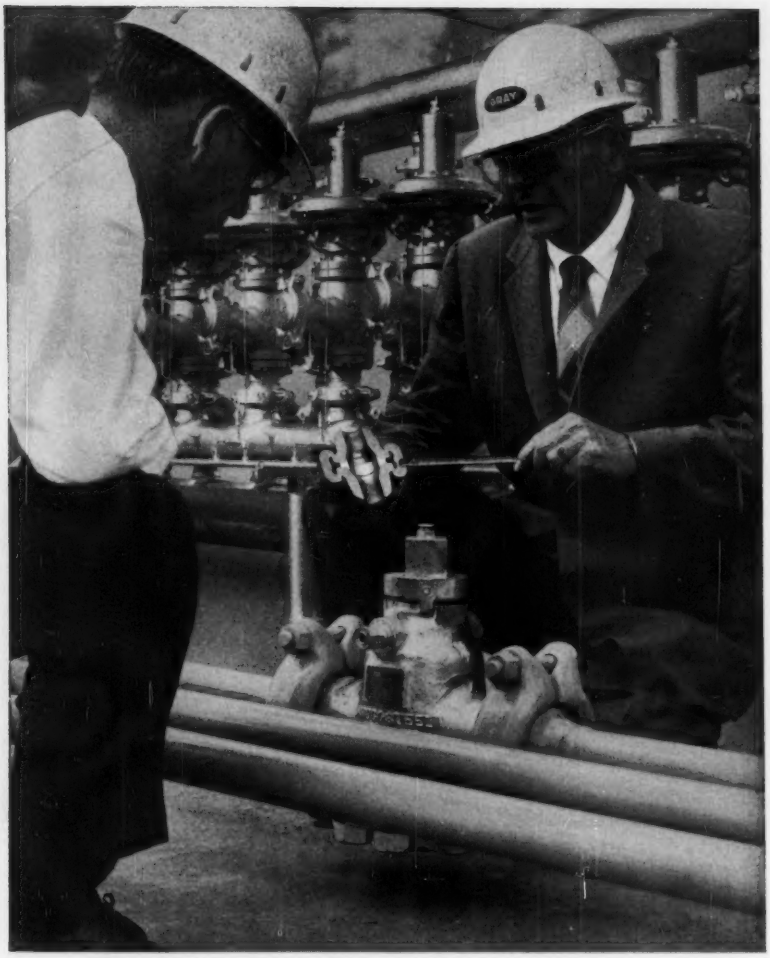
Send for details of these trouble-free turbines. Ask for a copy of bulletin S-116.

THE TERRY STEAM TURBINE COMPANY
TERRY SQUARE, HARTFORD 1, CONN.

TERRY

TT-1214

For more data on advertised products, use Readers' Service Cards, last page.



GRAYLOC® Seal: Leak-proof at any pressure

Leak-proof quality of GRAYLOC Seals in piping applications has been use-proved from full vacuum to 30,000 psi and test-proved up to 150,000 psi. Holding at any pressure makes GRAYLOC practical in applications requiring positive leak-proof connections.

The GRAYLOC Seal is available in two-bolt clamp-type or conventional flange connections. Its simple steel design features a rigid rib with lips on either side tapering slightly less than the mating hub to form a line seal at the touchpoint. As the connection is tightened, the lips deflect to form a surface seal. GRAYLOC connections provide a permanent steel seal that can be made up repeatedly, operating to pressure without seal ring replacement. Stock connections available from ½" to 30" and on special order in corrosion-resistant metals.

If you want to know more about how GRAYLOC Connections can permanently solve your leakage problems, write for the new GRAYLOC CATALOG on your company letterhead.

GRAYLOC SALES DIVISION

GRAY Tool Company

P. O. BOX 2291 HOUSTON 1, TEXAS Riverside 7-1240 05

Suppliers . . .

and transmission components, including adjustable speed-drives for the past 15 years.

J. I. CASE CO. has appointed **W. A. Smith** industrial service manager. Smith has been acting manager of industrial service and was formerly employed by the company as service and education manager, industrial, and assistant service manager.

FARRIS ENGINEERING CORP. has appointed **George E. Ellis** general sales manager. Ellis was formerly manager of the Industrial Products Division, Fairchild Engine and Aeroplane Corp., in their manufacture of turbo expanders, gas turbines, pneumatic regulators and compressors, and variable speed transmissions. He graduated from Ohio State University in business administration.

Ellis

MARSH INSTRUMENT CO. has completed construction of extensive warehousing and distributing facilities at Fort Lee, N. J. The warehousing set up will service the Eastern Seaboard requirements for Marsh products.

J. I. CASE CO. has named **A. B. Christensen** manager of the Central Services Division. Christensen joined the company in 1948.

DeLAVAL STEAM TURBINE CO.'s president, **James P. Stewart,** has been elected to the board of directors of the New Jersey Bell Telephone Co.

UNIVERSAL OIL PRODUCTS CO. has named **William G. Persons** products sales representative. Persons will service the West Coast and Hawaii, operating out of Downey, Calif.

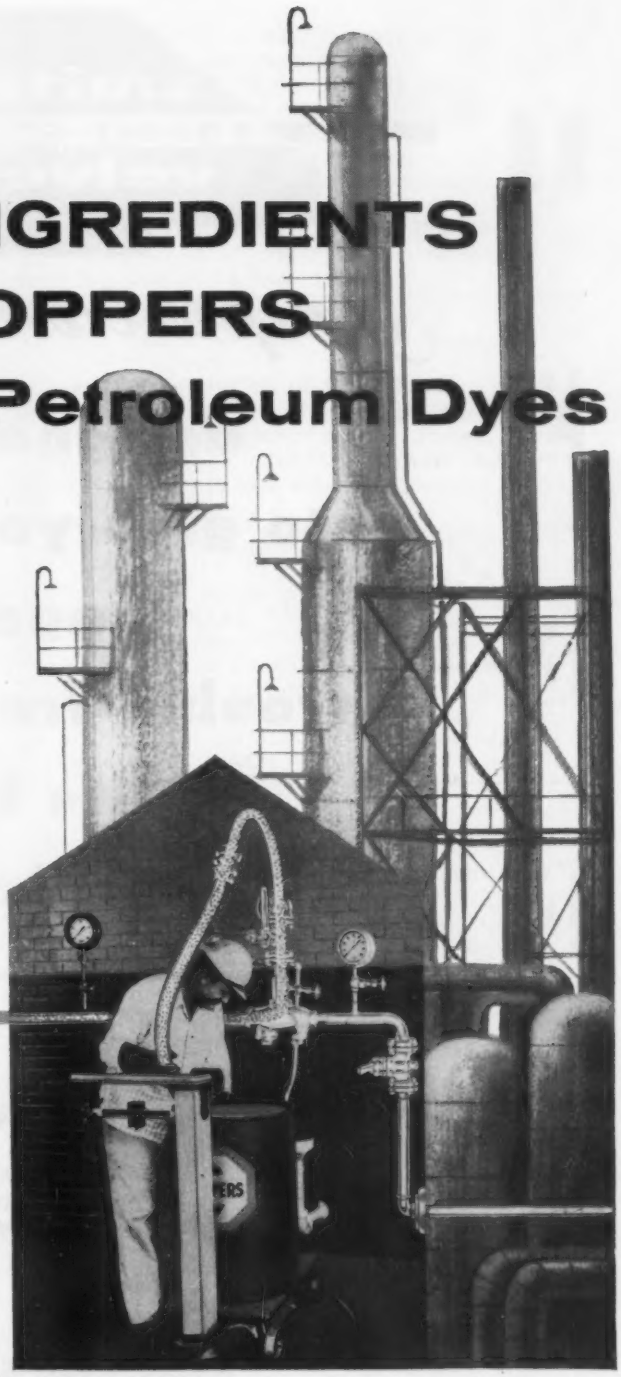
SCIENTIFIC AND PROCESS INSTRUMENTS DIVISION, Beckman Instruments, Inc. has opened a Boston sales office in Cambridge, Mass. The office is located at 12 Norfolk St., Cambridge 39, Mass.

VACUDYNE CORP. has appointed **John W. Maybaum** sales manager. Maybaum was formerly with Solar Chicago, division of U.S. Industries, as assistant general sales manager.

GRAVER TANK & MANUFACTURING CO. has elected **Robert W. Johnson** vice president, marketing and sales. Johnson will headquarter in East Chicago, Ind. Before joining Graver Tank, Johnson was vice president and general sales manager, Dunbar Kapple, Inc.

MERCURY CHEMICAL CORP., Edison, N.J., has opened a branch sales office in Charlotte, N.C.

PLUS INGREDIENTS in KOPPERS Gran-U-Flow™ Petroleum Dyes



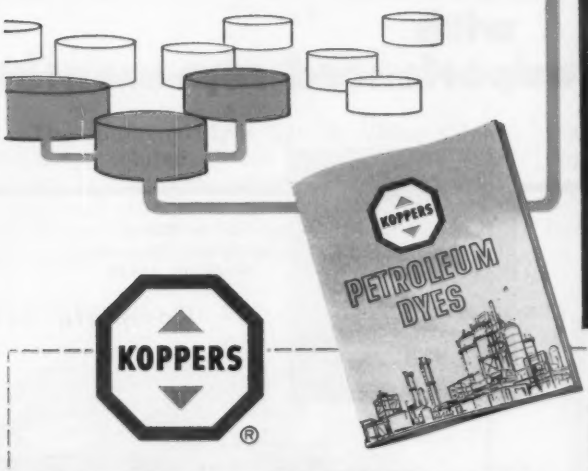
There *are* PLUS INGREDIENTS . . . in Koppers Gran-U-Flow Dyes . . . extra reasons why you should specify Koppers:

- unvarying uniformity . . . batch-to-batch
- high tinctorial strength
- dustless
- low benzene insolubles
- high solubility
- granular (Gran-U-Flow) . . . for *easy* flow

Whether you use petroleum dyes for gasoline, anti-freeze or a wide range of lubricants . . . for corporate identity, improvement of product appearance or ease of identification . . . you owe it to yourself to investigate the superior advantages of Koppers Gran-U-Flow Dyes.

Dye drums are color coded and designed for eductor systems in refineries.

Clip the coupon below to your company letterhead for a booklet showing newest eductor techniques. A free laboratory kit is also available. VMA 6982



KOPPERS®

KOPPERS COMPANY, INC.

Chemicals and Dyestuffs Division

KOPPERS BUILDING, PITTSBURGH 19, PA. • **Plant:** Lock Haven, Pa.
Branches: Providence, R. I. • Philadelphia, Pa. • Paterson, N. J. • Chicago, Ill. Charlotte, N. C. • Chattanooga, Tenn. • Columbus, Ga. • Los Angeles, Calif. Houston, Texas • **Dominion Anilines & Chemicals, Ltd.,** Toronto, Canada

☐ Please send booklet on newest eductor techniques.

☐ Please send free laboratory kit for Gran-U-Flow Petroleum Dyes.

Name_____ Title_____

Company_____

Address_____

City_____ Zone_____ State_____

CLIP TO YOUR COMPANY LETTERHEAD.
Mail to our Pittsburgh office or nearest branch.

For more data on advertised products, use Readers' Service Cards, last page.

smith FORGED STEEL valves ...for 1961 - with FOUR *Important improvements*

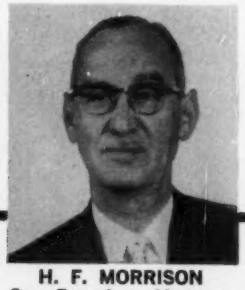
designed to give you longer, trouble-free life in service

SMITH Forged Steel Valves for 1961 have been redesigned and improved to meet the higher standards of quality and efficiency now demanded by the Refinery, Chemical and Petrochemical Industries.

As the result of design and material improvements in four vital operational areas, SMITH Valves can now be relied upon to give better performance than ever before—performance which means longer, trouble-free life in service with the very minimum of maintenance cost.

with experienced representation

JACK R. B. FREEMAN
West Coast Manager
Los Angeles, Cal.



H. F. MORRISON
San Francisco Manager

W. A. BOLES
Southwest Manager
Houston, Texas

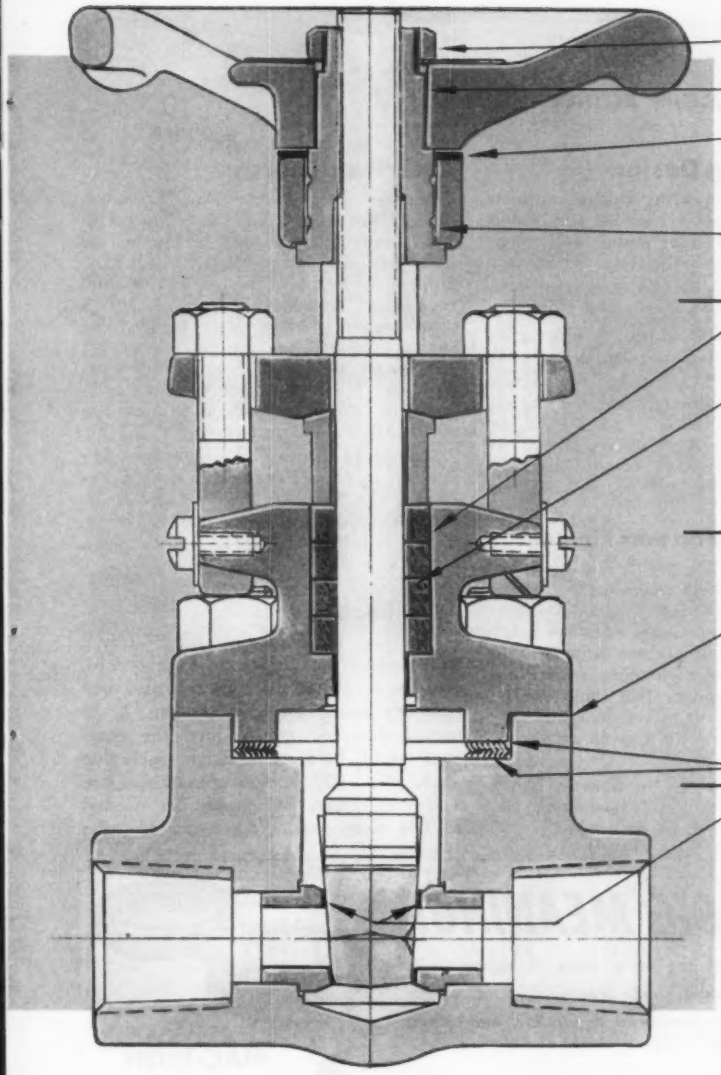
W. L. WOOD
Midwest Manager
Chicago, Ill.

Complete factory

NEW ENGLAND

41 Jackson Street

New England Valve Corporation



- **LOCK NUT** for easy removal of handwheel. Handwheel
- **BROACHED TO FIT SQUARE** on operating nut — no key required.
- **HARDENED STAINLESS STEEL THRUST WASHER** between handwheel and bonnet eliminates seizing and galling.
- **MOLY-DISULPHIDE LUBRICATED** oil grooves in operating nut insure permanent ease of operation.

1

- **REENGINEERED STUFFING BOX** results in 50% greater sealing efficiency.
- **1200° F. PREMIUM PACKING** — uniformly compressed, graphited Asbestos, Inconel wire-reinforced. Packing includes a proven inhibitor to insure against corrosive damage.

2

The redesigned body-bonnet joint allows a 25% increase in the spiral wound gasket sealing area.

- **CONTROLLED TAKEDOWN,** as recommended by leading engineers in the field of spiral wound gaskets, provides the ultimate in sealing efficiency. Tongue and groove surfaces are machined to
- **63 MICRO-INCH FINISH.**

3

- **STELLITE-FACED SEATS.** In cooperation with the Haynes Stellite Company, we have developed a new machine for hard facing our seat rings with Stellite #6. These hard faced seats (400 BNH) and the hard gate (500 BNH) lapped to a 2-3 micro-inch finish result in a positive tight seal and a greatly extended service life.

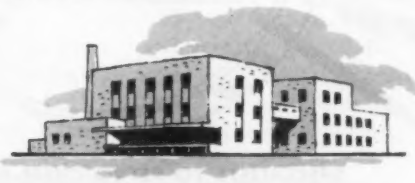
4

and expanded service facilities . . .

The four top-flight SMITH Valve sales executives pictured on the opposite page are veterans in the valve business. They represent a combined experience of more than 60 years. They know the valve problems of your industry and are well qualified to assist you in selecting the SMITH Valves which best meet your requirements.

We are also expanding our service facilities to insure the prompt delivery of SMITH Valves on time — when you need them.

stocks available at Los Angeles, Houston and Worcester



VALVE CORPORATION

Worcester • Massachusetts

of Canada, Ltd. • Factory and offices: 1862 Mattawa Avenue, Summerville, Ontario

For more data on advertised products, use Readers' Service Cards, last page.

New Books...

As selected by the editors of PETROLEUM REFINER

Oil for the World

"Oil for the World" is an introduction to fuel energy. The book reviews the major contributions of oil to human welfare and to world economy. The reader may learn, in non-technical language, the fundamentals of petroleum geology and petroleum engineering—how oil is formed in the earth and how it is found, produced and refined.

One can also learn how wells are drilled, how the crude oil is drawn from the wells, and how it is transported to refineries. There is information on the processes of refining that produce a large variety of products, including the fast-growing petrochemicals. There is a section on research, which has improved gasoline, fuel oil, and lubricants, and which has developed many new products derived from oil.

All the important phases of the industry are covered, including the geographical locations of oil-producing areas, the conservation of oil as a major natural resource, the essential facts about tankers, pipelines and oil barges, and the elements of distribution and marketing.

(Drake, N. D'Arcy; Schackne, Stewart, *Oil for the World,* Harper & Brothers, 49 East 33rd St., New York 16, N.Y., 140 pages, $2.50.)

Engineering Design

"Creative Engineering Design" outlines and discusses ways to "get off the beaten path." Concrete suggestions and techniques are given that will enable one to:

- gain confidence and proficiency in the application of tools;
- keep a flexible approach using trial and error, intuition, association, adaptation, and the like;
- change your thought habits to admit imagination with reason.

(Buhl, Harold R., *Creative Engineering Design,* The Iowa State University Press, Ames, Iowa, 195 pages, $3.95.)

Guide to European Firms

"Petro-Chem Guide to Europe" describes briefly the 400 chemical and petroleum firms in 18 countries of Western Europe. For each country, firms are listed alphabetically. The address is given, and in most cases, other company affiliations, if any. A sentence or two indicates the main products made by the company. Occasionally, capacity for a given product is given.

(*Petro-Chem Guide to Europe,* Noyes Development Corp., 38 East 57th St., New York 22, N.Y., 66 pages, $12.)

American Energy

"Energy in the American Economy, 1850-1975: Its History and Prospects" is a comprehensive study of energy use and availability in the United States. The study looks back over the past century and ahead for the next 15 years. It brings together and analyzes data on the important sources of commercial energy; projects the nation's energy requirements up to 1975; and inquires into the adequacy of domestic resources to meet the projected 1975 requirements.

(Netschert, Bruce C.; Schurr, Sam H.; and others, *Energy in the American Economy, 1850-1975: Its History and Prospects,* the Johns Hopkins Press, Homewood, Baltimore 18, Md., 774 pages, $12.50.)

Job Security

"We Can Maintain Our Job Security" is a booklet that expounds on five cold, hard facts: (1) to have job security, your company must first have profits, (2) to outsell domestic competitors, the company must hold costs down, including wage costs, (3) foreign competitors are a special threat, (4) profits are needed to buy new tools, (5) increased sales

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Not a mere name plate, this little metal tag on a piece of equipment is unreserved assurance of quality workmanship and dependability of service . . . priceless characteristics not solely measured in dollars and cents.
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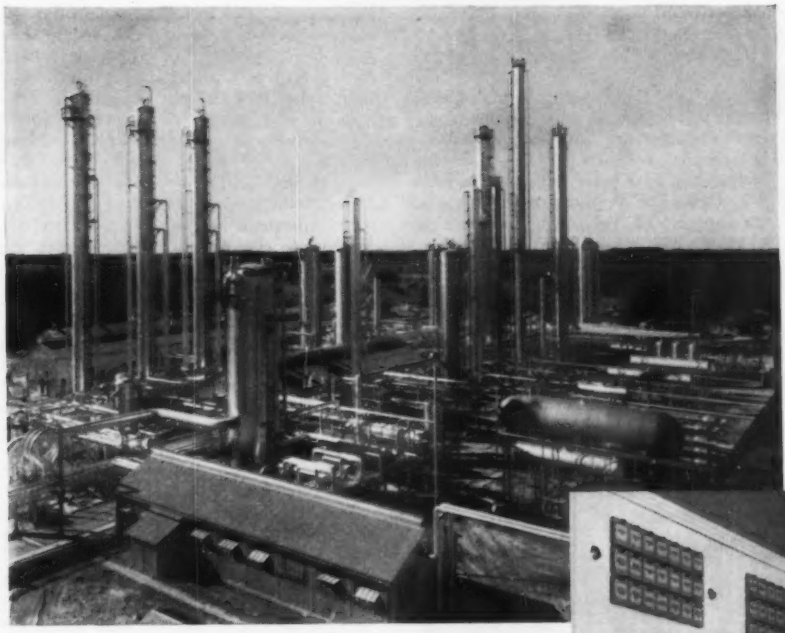


Part of the Arkansas Louisiana Chemical Corporation's new Hamilton Plant at Magnolia, Arkansas. Below, the central control panel, designed by Delta Engineering Corp. Note the compatability of the Taylor TRANSCOPE Recorders, Single-Case Cascade instruments and Ratio Relays.

Hamilton Gasoline Plant of ARKLA gets exceptionally high product purity with *Taylor* TRANSCOPE® control

Redesigned and rebuilt by Delta Engineering Corporation, Houston, Texas, the Hamilton Gasoline Plant of Arkansas Louisiana Chemical Corporation uses a variety of Taylor temperature, pressure and flow transmitters. The very compact central control panel includes scores of TRANSCOPE Recording Control Stations. It also features such innovations as Ratio Relays and Single-Case Cascade instruments which reduce panel space requirements and simplify operational control.

The plant operating personnel report that the instruments have performed to their complete satisfacfaction ever since the new plant went on stream.

The Hamilton Plant was designed to process a gas throughput of 400,000 MCF per day, utilizing a refrigerated, low-molecular weight oil absorption process. This involves processing 350,000 MCF of gas at 800 psig and 50,000 MCF at 575 psig from various gas fields connected to the plant. The fractionation system separates and puts into storage 200,000 gallons per day of propane, iso-butane, normal butane, isopentane and 18# RVP gasoline. It has the capacity to recover 85,000 gallons daily of ethane which could be doubled by minor additions to the plant.

Here is another fine example of the dependability and accuracy of the TRANSCOPE line of instruments and associated transmitters. Ask your Taylor Field Engineer for a demonstration, or write for bulletin. Taylor Instrument Companies, Rochester, N. Y., or Toronto, Ontario.

***Taylor Instruments* MEAN ACCURACY FIRST**

For more data on advertised products, use Readers' Service Cards, last page.

Books . . .

mean more job security. In short, you've got to work to help keep the golden goose alive—or else!

(Riegler, Charles, *We Can Maintain Our Job Security,* Employee Relations, Inc., 13 East 53rd St., New York 22, N. Y., 16 pages, 25¢.)

Abstracts of Theses

"Abstracts of Theses Accepted in 1958-1959" consists of 188 theses accepted for the doctor's degree at the Massachusetts Institute of Technology in the 1958-59 academic year. The paper-bound book also lists the titles of theses presented for engineer's and master's degrees during the year.

Microfilms or photoprints of each complete thesis text may be ordered from MIT by reference to the publication. Photoprint copies of the engineer's and master's theses are also available on a similar basis.

(Abstracts of Theses Accepted in 1958-1959, Office of Publications, Massachusetts Institute of Technology, Cambridge 39, Mass., 288 pages, $3.50.)

Installation Manual

"API RP 550, Manual on Installation of Refinery Instruments and Control Systems," covers the installation of the more generally used measurement and control instruments and related accessories. It consists of sections on flow, level, temperature, pressure, automatic controllers, control valves and positioners, transmission systems, seals, purges and winterizing, air supply systems, electrical power supply, hydraulic systems, and instrument panels.

(API RP 550, Manual on Installation of Refinery Instruments and Control Systems, American Petroleum Institute, 1271 Avenue of the Americas, New York 20, N.Y., 107 pages, $4.)

Professional Engineers

"Engineering Professionalism in Industry" is the sixth survey in a series made for the Professional Engineers Conference Board. Primary objective of the study was to find out what engineers and engineering managers mean by professionalism, and how they think it can best be advanced.

The engineers and managers interviewed all work for large companies that employ many engineers and are located in various parts of the country from the East to the West Coast.

(*Engineering Professionalism in Industry,* Opinion Research Corp., Research Park, Princeton, N.J., 104 pages, $2 for National Society of Professional Engineers members, $4 for non-members.)

Gas Measurement Course

"Proceedings of the Thirty-fifth Southwestern Gas Measurement Short Course" reports both technical and non-technical material whereby the men in industry may study problems pertaining to the measurement and pressure regulation of dry and casinghead gas.

The papers are divided into the following broad headings:

- Measurement by orifice.
- Regulators, Controls, and related equipment.
- Measurement by displacement.
- Gas Accounting.

(*Proceedings of the Thirty-fifth Southwestern Gas Measurement Short Course,* The University of Oklahoma, Norman Okla., 417 pages, $6.)

Processing Nomographs

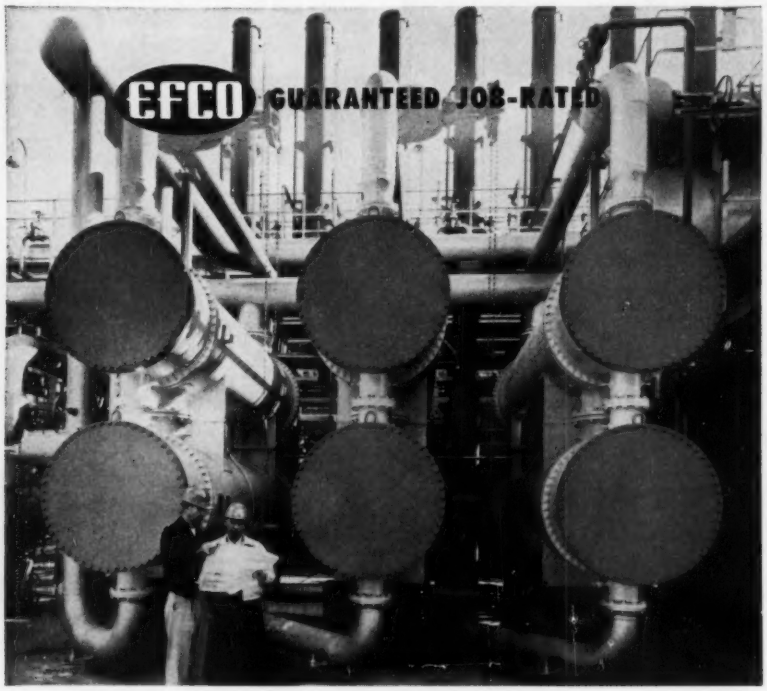
"Chemical Processing Nomographs" is a bound volume of 165 nomographs. Each nomograph in the book is the contribution of a recognized expert in his respective specialty. Dale S. Davis serves as consulting editor to these nomographs.

(Davis, D. S., editor, *Chemical Processing Nomographs,* Chemical Publishing Co., Inc., 255 pages, $12. For sale by Gulf Publishing Co., P.O. Box 2608, Houston 1, Texas.)

Products and Lubricants

"ASTM Standards on Petroleum Products and Lubricants" contains 168 standards of which some 31 are new, revised, or have had their status recently changed. The compilation is being published in two volumes for the first time.

Volume I will contain most of the ASTM standards on petroleum including crude petroleum, butadiene, motor and



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Years of experience in engineering and fabricating of heat exchangers for the wide range of temperatures/pressures encountered in refining-petrochemical-natural gasoline plant processes enables EFCO to offer service-proved engineering design and guaranteed job rating. Mobil Chemical Company is one of many process equipment users who are benefiting from EFCO's specialized experience and engineering efficiency.

This Mobil Chemical Company installation of EFCO exchangers, in the world's largest ethylene unit at Mobil's Beaumont, Texas plant, is typical of the many high-pressure, high-temperature exchangers designed and fabricated by EFCO.

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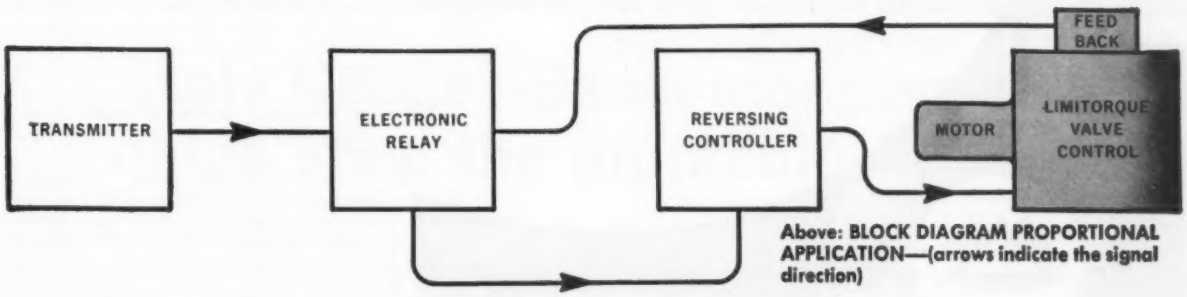
VALVE OPERATORS

with Proportional Positioning for Remote Manual, and Completely Automatic Operation

The growing demand for complete process control systems to assure the centralization of performance responsibility in a single source, is successfully accomplished by systems employing LimiTorque (some of which are outlined in Bulletin #6-60 offered here). The same dependability and accuracy that has made the name LimiTorque so widely used and favorably known throughout the World on all types of installations, is maintained in these modern all-electric actuator systems.

Full range proportional operation of the final control element from remotely located electronic transmitters, provide answers that the process engineers need, to automatically throttle in response to process variables such as pressure, flow, level, density, weight, thrust, temperature, position, etc. Components employed in the LimiTorque system are chosen for dependability with the elimination of complex circuits and special electrical power supplies. Inquiries are invited to meet the exacting service requirements.

Be sure to send for this New Bulletin 6-60 which fully describes and profusely illustrates LimiTorque with Proportional Positioning accessories.



Above: BLOCK DIAGRAM PROPORTIONAL APPLICATION—(arrows indicate the signal direction)

THERE IS NO SUBSTITUTE FOR —

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Offices in all Principal Cities

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For more data on advertised products, use Readers' Service Cards, last page.

aviation fuels, naphthas, diesel fuels, lubricating oils, industrial oils, cutting oils, turbine oils, greases, waxes, spray oils, and other related materials.

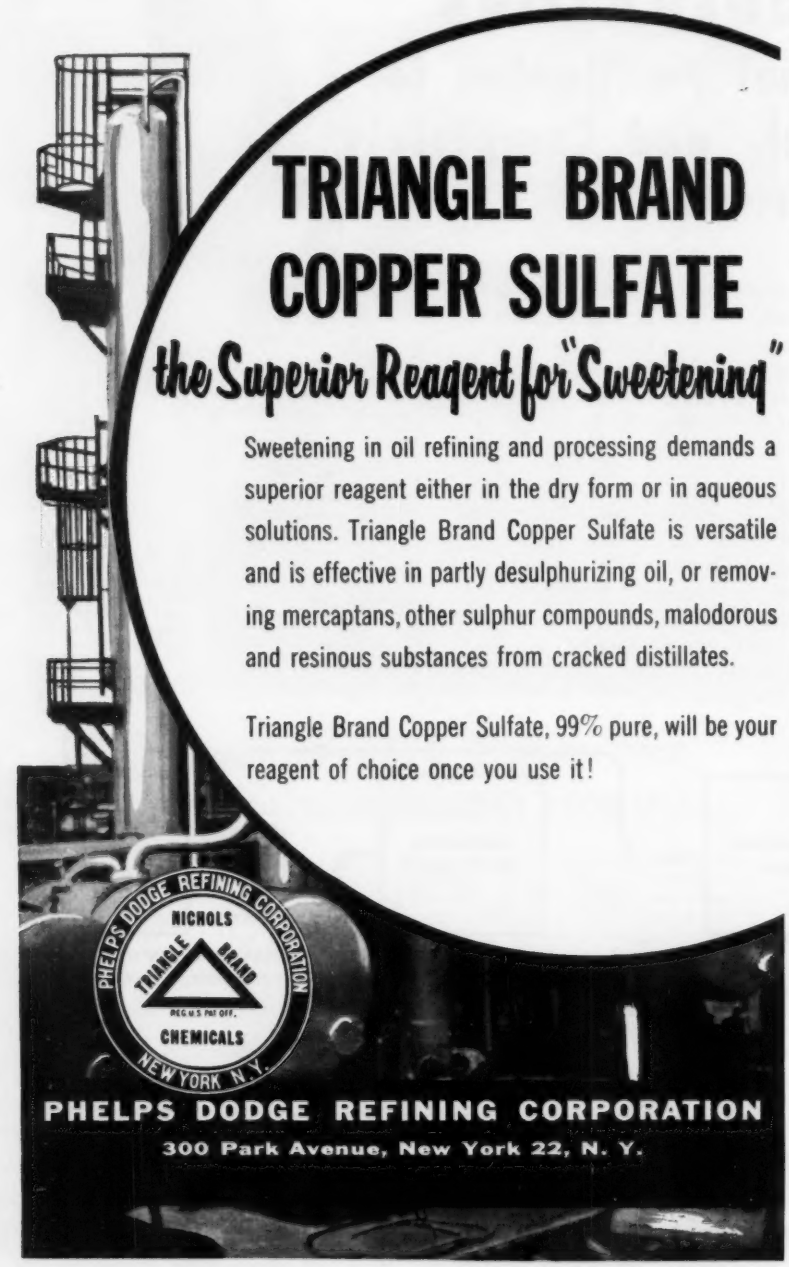
Volume II will not be available until later. It will include a number of standards relating to: solvents (D-1), gaseous fuels (D-3), bituminous road and paving materials (D-4), waterproofing and roofing materials (D-8), electrical insulating oils (D-27), industrial aromatic hydrocarbons (D-16), wax polishes (D-21), general methods of test (E-1), nomenclature and definitions (E-8), quality control (E-11), and absorption spectrometry (E-13).

(*ASTM Standards on Petroleum Products and Lubricants,* American Society for Testing Materials, 1916 Race St., Philadelphia 3, Pa., 1,130 pages, $9.50.)

Gas/Oxygen Flames Tables

"Tables for Petroleum Gas/Oxygen Flames" presents tables of the combustion products and their thermodynamic properties over a wide range of temperatures for a selection of liquefied petroleum gases (LPG)/oxygen flames.

(Berenblut, I. I.; Downes, Anne B., *Tables for Petroleum Gas/Oxygen Flames,* Oxford University Press, 417 Fifth Ave., New York 16, N.Y., 107 pages, $4.80.)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Sweetening in oil refining and processing demands a superior reagent either in the dry form or in aqueous solutions. Triangle Brand Copper Sulfate is versatile and is effective in partly desulphurizing oil, or removing mercaptans, other sulphur compounds, malodorous and resinous substances from cracked distillates.
Triangle Brand Copper Sulfate, 99% pure, will be your reagent of choice once you use it!
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Piping Specifications

"ASTM Specifications for Steel Piping Materials" covers (1) pipe used to convey liquids, vapors, and gases at normal and elevated temperatures, (2) still tubes for refinery service, (3) heat exchanger and condenser tubes, and (4) boiler, superheater, and economizer tubes. To complete the volume, there are also included specifications for castings, forgings, bolting, and welding fittings used in such installations.

Over half of the approximately 70 specifications in the book have been revised since the 1959 edition was published. Many of the specifications for tubular products have been changed to include a more detailed description of the flattening test.

(*ASTM Specifications for Steel Piping Materials,* American Society for Testing Materials, 1916 Race St., Philadelphia 3, Pa., 524 pages, $7.)

Productivity Planning

"Planning for Productivity in the Oil Industry" contains general discussions of the latest developments in most phases of the petroleum industry. It is a report of a meeting held in Bournemouth, England, May 1960. Two of the six papers included concern problems of direct interest to refiners: Application of the Computer to Refinery Programming, and Modern Laboratory Control of Product Quality.

(Sell, George, editor, *Planning for Productivity in the Oil Industry,* The Institute of Petroleum, 61 New Cavendish St., London, W.1, England, 161 pages, $4.90 to non-members of the institute, $4.20 for members.)

Top Management Handbook

"Top Management Handbook" has been prepared by 60 business leaders from both large and small companies. It provides a source of information, both on management fundamentals and their own proved practices. Basically, the book deals with what management is, not only at the top level, but also in each area of activity management; what is called for in the manager's thinking and ability; and how it can be carried out for the good of the company, manager and society. It covers each function of management from the viewpoint of the top executive (usually the president) as well as heads of sales, production, marketing and finance activities.

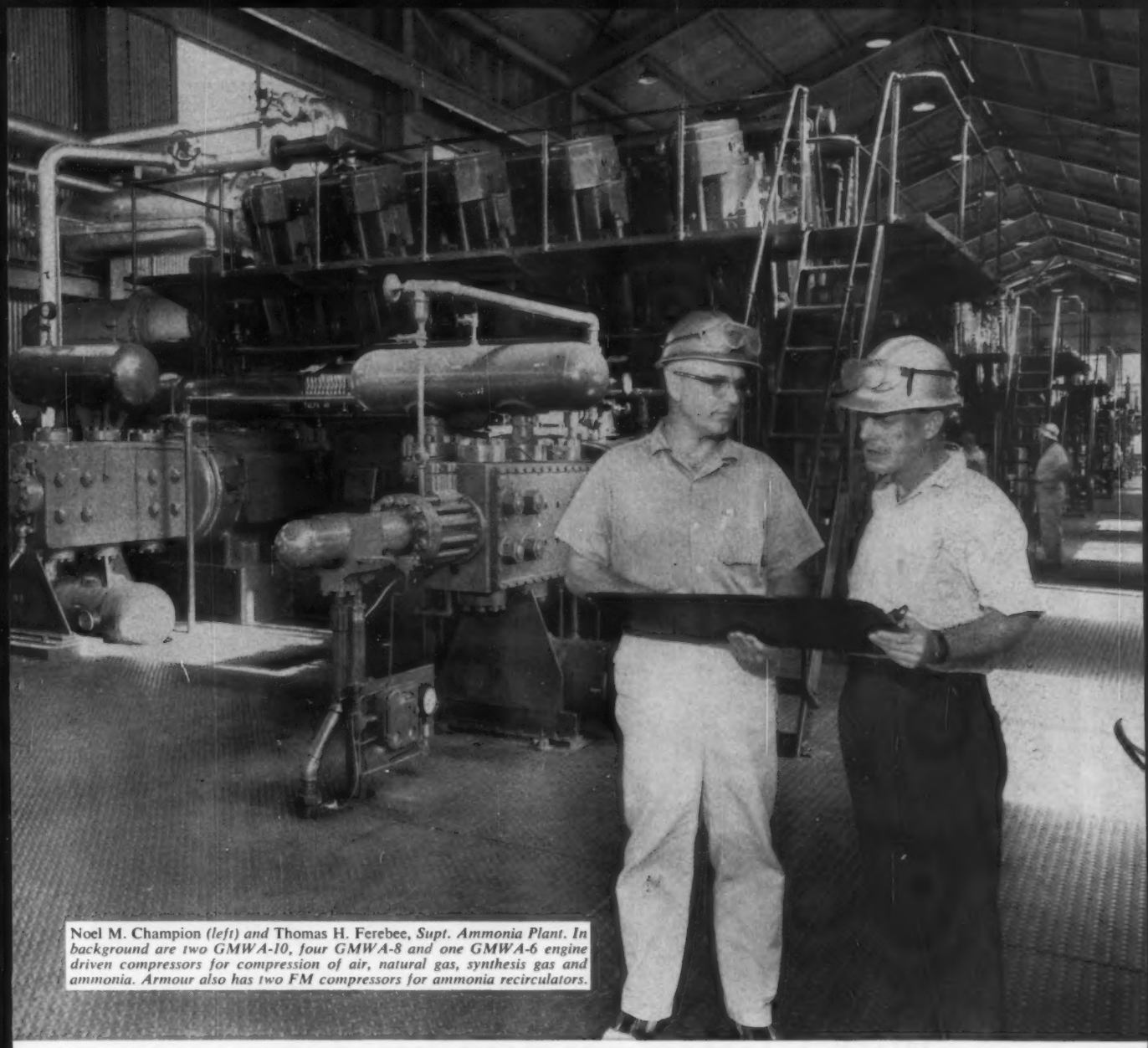
(Maynard, H. B., editor, *Top Management Handbook,* McGraw-Hill Publishing Co., 1,236 pages, $17.50. For sale by Gulf Publishing Co., P. O. Box 2608, Houston 1, Texas.)

Instrument Installation

"ISA-RP 12.1" provides recommended methods of electrical instruments installation. It also covers in detail several often overlooked aspects which are common to each of the various methods of protection.

(*ISA-RP 12.1,* Instrument Society of America, 313 Sixth Ave., Pittsburgh 22, Pa., six pages, 50¢ to ISA members, 75¢ to non-members.)

For more data on advertised products, use Readers' Service Cards, last page.



Noel M. Champion *(left) and* Thomas H. Ferebee, *Supt. Ammonia Plant. In background are two GMWA-10, four GMWA-8 and one GMWA-6 engine driven compressors for compression of air, natural gas, synthesis gas and ammonia. Armour also has two FM compressors for ammonia recirculators.*

How Cooper-Bessemer service helps keep the ammonia flowing

At Armour Agricultural Chemical Co., Crystal City, Missouri, nine Cooper-Bessemer compressors play key roles in the manufacture of ammonia products. Round the clock, for five years, these units have given exceptional performance under the rigors of such problems as handling pressures up to 9000 psi.

The performance of these C-B compressors has been backed by Cooper-Bessemer engineers in the St. Louis area and in Mt. Vernon, contributing helpful service for these high-pressure operations.

Cooper-Bessemer engineers will gladly help *you* plan compression facilities, and demonstrate how this unique service works for your benefit. Call the nearest office.

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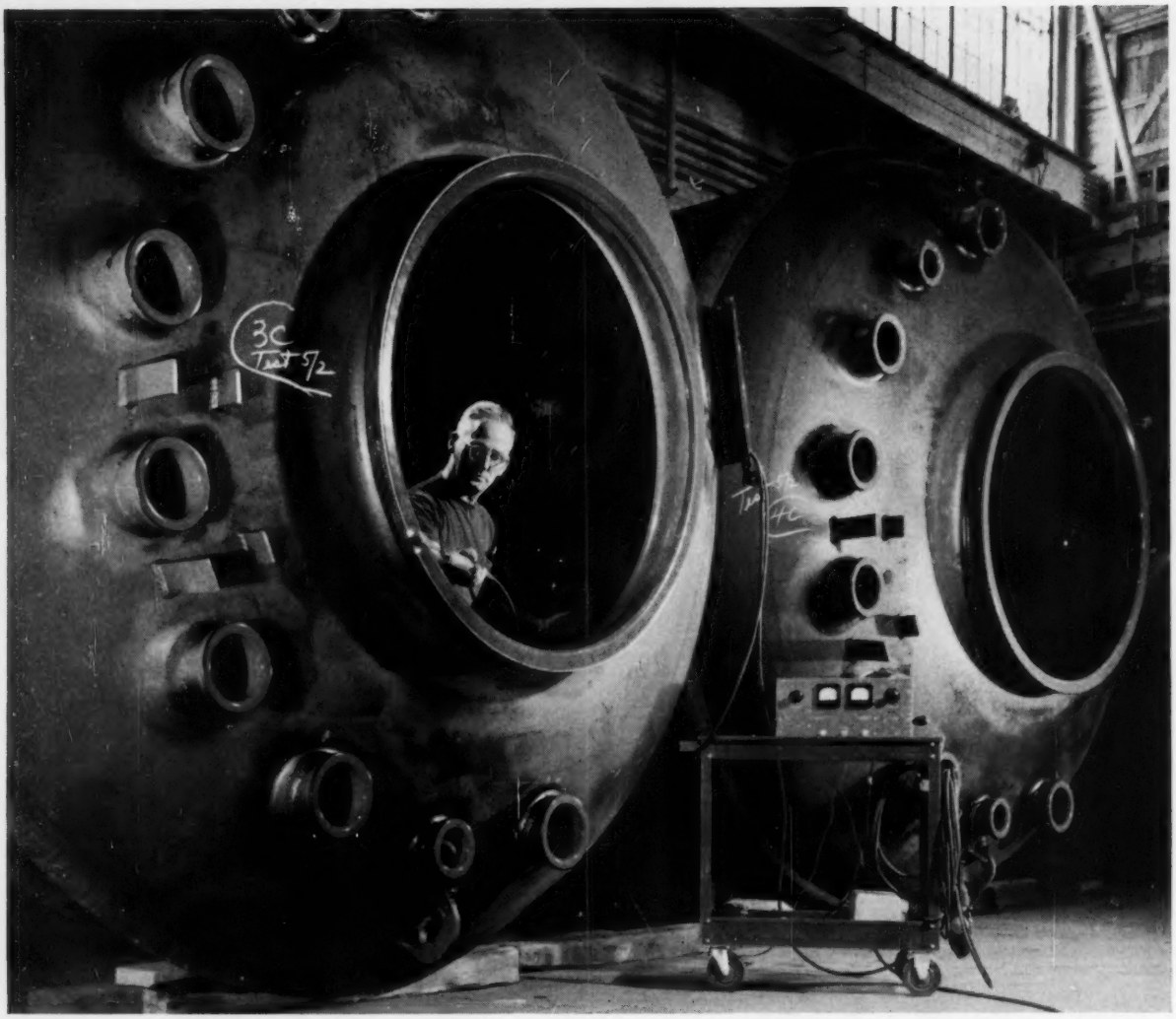
FLUIDICS* AT WORK



With Glasteel reactors you get a full-year guarantee against corrosion

This man is electric testing the interior of a Pfaudler® Glasteel reactor. He's making sure that every inch of the inside product-contact surface is completely covered with corrosion-resistant glass.

That's the *glass* in Glasteel. Outside there's *steel* for working strength. Fusing the two together gives you a combination that lets you forget—rather than fight—corrosion.

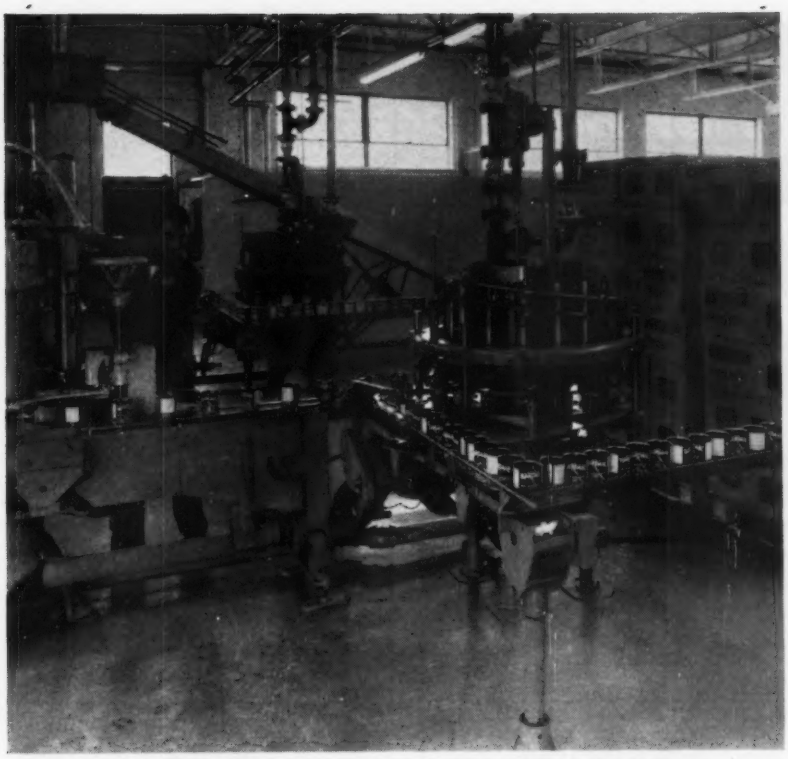
Guaranteed resistant. Glasteel has a natural resistance to corrosive attack. You can use it safely with all solutions of all acids except HF to 212° F (even up to 450° F for certain acid solutions, depending on concentration) and with many alkalies at moderate temperatures. You can do so with complete confidence, since Pfaudler Glasteel equipment is guaranteed against corrosion for a full year after shipment, when used under operating conditions specified and approved. If rendered unusable by chemical attack during this period, Pfaudler will repair or replace it, f.o.b. factory.

Protection plus. That's only part of the story. Glasteel also is inert; it won't influence quality, flavor, color or purity of your products. And its smooth, abrasion-resistant surface resists product buildup. Heat transfer is not impeded by surface fouling by product or corrosion, and cleaning is both quick and complete with a minimum of effort.

Wide choice. You can put these advantages of Glasteel to work in many ways. Select from one-piece, all-welded reactors in standard sizes from 300 to 4,000 gallons—custom designs to 10,000 and even larger. You can also get polymerizers, columns, storage tanks, pumps, pipe, valves and fittings in a range of sizes.

Sound investment. You'll find that Glasteel is actually lower in cost than many of the specialty alloys your processes may require. And Glasteel is your soundest investment when long service life is considered.

More facts. Bulletin 988 spells out the details on Glasteel reactors and Bulletin 932 covers Glasteel polymerizers. For your copies, write to the address shown on the facing page.



Two Pfaudler Rotary Piston Fillers package a variety of viscosities and container sizes at Bardahl Lubricants Inc., Norwood, Mass.

No filler maintenance in two years at Bardahl

No maintenance. No parts replacement. That's the performance record for these Pfaudler RPL-14 Rotary Piston Fillers after *two years* of service.

Bardahl runs this production line with these two fillers handling oils which vary in viscosity from SAE-5W to SAE-50W. Filling rates are as follows: 4-oz. containers at 260 cans per minute, 15-oz. at 225 cans per minute, and quarts at 190 cans per minute.

These are *not* the top operating speeds for the RPL-14, since they are geared to Bardahl's *current* production requirements. Actually, these machines are capable of 350 quarts per minute.

Bardahl tolerates *no* spillage – and none occurs in this installation. One reason why you might consider Pfaudler fillers in your plant. Other reasons?

Simplicity is a key factor. Pfaudler fillers offer a design in which piston and valve can be disassembled without tools in a few minutes.

There are no connecting rods or wrist pins to wear out, no piston rings.

You can quickly clean and visually inspect both filler bowl and valve body. And all gearing is totally enclosed in an oil bath.

Accuracy can be held to ±1/10 of an ounce for most materials. You can adjust fill accuracy from a single control point, *without* stopping the machine.

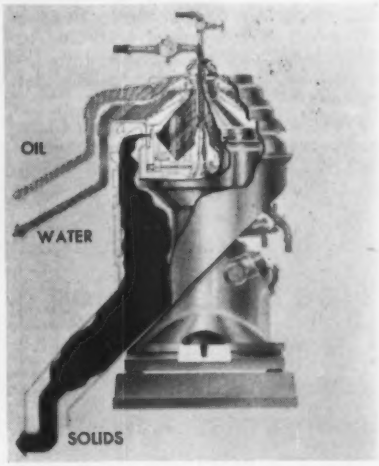
Matched to your needs. The RPL-14 is one of a complete line of fillers from Pfaudler, each designed to meet specific oil-packaging requirements. For example, the RPL-36 can handle as many as 800 quarts per minute.

More information. Bulletins No. 964 and No. 878 give specs on the Pfaudler line of fillers for oil packaging. Write for copies to the address shown on this page.

*FLUIDICS is the Pfaudler Permutit program that integrates knowledge, equipment and experience in solving problems involving fluids.

How to squeeze more profit out of tank-bottom sludge

Here's a centrifuge that can really add measurably to what you recover from tank bottoms.



With a Pfaudler Titan Superjector you get a 3-way split of oil-water-solids simultaneously in a single pass.

With this Titan Superjector you can efficiently separate oil-water-solids simultaneously, *in a single pass*. You have a settling power up to 7500 times gravity, much more force than you get with most continuous centrifuges.

Equally important, sludge discharge is through slots—*not* nozzles. These slots are 3/8 inch by 5 inches and handle drier, more compacted sludges with particles up to 1/8 inch in diameter. There is no down time for cleaning bowl or clogged nozzles. Adjusting the hydraulic controls accommodates varying solids content of the feed and desired sludge dryness.

We'll run tests in our Engineering Test Center or *in your plant* with a portable production unit. More details found in Bulletin 946. Write for your copy.

New Glasteel bulletin

All the pertinent data on Glasteel, the *material of construction*, have now been brought together in a single full-color brochure.

It's Bulletin 985, and in its 20 pages you'll find 16 pages of *technical data* on thermal shock, operating temperatures, specifications, and corrosion resistance. Write for your free copy today.

Please address all inquiries to our Pfaudler Division, Dept. PR-31, Rochester 3, New York.

PFAUDLER PERMUTIT INC.

Specialists in FLUIDICS . . . the science of fluid processes

Books . . .

Clean Air

"Proceedings of the International Clean Air Conference" contains the 78 papers, from 17 countries, that were presented in printed form at the International Clean Air Conference in London in October 1959. Grouped according to subject, the papers in each session are included with the general discussions that followed.

(*Proceedings of the International Clean Air Conference,* National Society for Clean Air, Field House, Breams Buildings, London, E.C.4., England, 290 pages, $4.75.)

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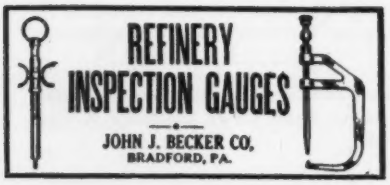


JOHN J. BECKER CO.
BRADFORD, PA.

■ Twelve HCL Acid Resistant Burners 4½ feet wide, 27 feet long. 5000 Harbison-Walker SID 60 Book Bricks in each Burner. One Burner has never been used. Very reasonable—contact Southern Scrap Material Co., Inc., P. O. Box 1133, Baton Rouge, La.

Petroleum Refiner Classified Ads

RATES: **Regular Classified** (undisplayed) set in this type: 20 cents per word. Minimum charge, $4. Blind box address in our care counts six words. Replies forwarded without charge. **Display Classified ads,** set in suitably larger type with ruled border $13.50 per column inch. Ten percent discount for two or more insertions of same copy in consecutive issues. **All Classified ads payable in advance.** Copy deadline: 25th of month preceding date of issue. Send copy and checks to: Classified Advertising, Petroleum Refiner, P. O. Box 2608.

HELP WANTED

PROCESS ENGINEER

Position available for graduate Chemical Engineer with minimum 2 years experience processing work on light hydrocarbon or petrochemical plants.
Call or Write
T. D. TABBERT
Chief Process Engineer
The Fish Engineering Corp.
796 M & M Building
Houston, Texas

PROCESS ENGINEERS

McKee of Cleveland, Ohio offers permanent career opportunities with a rapidly expanding professional organization. Individuals possessing a minimum of 10 years experience in the design of petroleum, petro-chemical or general chemical producing facilities will be afforded unlimited advancement opportunities.

Reply in confidence to:
G. VICTOR HOPKINS
Arthur G. McKee & Company
2300 Chester Ave., Cleveland 1, Ohio

TECHNICAL SALES REPRESENTATIVE

Our company is expanding rapidly and we need help. We are presently located in Tyler, Texas, and expect to relocate in the Chicago area within a year and a half.

We are interested in you if you:
—Have 2 to 8 years experience in petroleum refining and a B.S. in Chemical Engineering
—Are aggressive, like sales work, and prefer to work with minimum supervision
—Want a job where you are badly needed and your efforts will be properly rewarded
—Don't mind traveling

Send resume and photograph to:
R. J. Phillips, President
HOWE-BAKER ENGINEERS, INC.
P. O. Box 956
Tyler, Texas **Phone LYric 3-6411**

■ West Coast Engineering Company has a senior position for a qualified Process Design Engineer, proficient in electronic computer programming and application. Send complete resume to Box 350-R, Petroleum Refiner, Houston, Texas.

■ Petroleum Refinery Engineer. Duties include testing, production, process development, equipment design. Location: Jacksonville, Florida. Remuneration: Salary plus pension, bonus, stock-option plans. Opportunity for advancement depends on individual. Send resume of experience. Request last school you attended to forward transcript of record. Send personal history, including photograph, to ALLIED PETRO-PRODUCTS, INC., 1445 City Line Av., Philadelphia 31, Penna.

■ CHIEF CHEMIST: Independent refiner seeking a chemist or chemical engineer with experience in lubricating oils. Position entails direction of new research facility as well as supervision of control laboratory. Applicants must be experienced to be considered—Southern inland location. Write Box 347-R, PETROLEUM REFINER, Houston, Texas.

Chemical Engineers

BS or MS degree plus 2 to 5 years experience. Outstanding opportunities for professional development and advancement with a growth-minded company. Process design, technical service and economic evaluations related to petroleum refining and petrochemical processes. Submit resume to:

Manager Coordination and Technical Department
COSDEN PETROLEUM CORP.
BIG SPRING, TEXAS

PROCESS DESIGN ENGINEER

Outstanding opportunity with Independent Oil Company on West Coast for graduate Chemical Engineer with at least 5 years experience in petroleum refining and petro chemical plants. Qualifications emphasize new project planning and design with background in operations, design and technical services.

INQUIRIES HELD CONFIDENTIAL

Forward resume to
Box 351-R
Petroleum Refiner
P. O. Box 2608
Houston 1, Texas

Babbitt *Adjustable* **SPROCKET RIM**
with Chain Guide
CHANGES THAT DANGER ZONE TO A SAFETY ZONE

. . . cuts costs when you SIMPLIFY PIPE LAYOUT

When you modernize to make money, go all the way. Cut piping costs to minimum with planned simplification. Give your staff a free hand to effect economics—at the same time, convert Danger Zones to Safety Zones. Equip every overhead valve wheel in your plant with Babbitt Adjustable Sprocket Rims with Chain Guides.

- They simplify pipe layout.
- They fit any size valve wheel.
- They are easy to install and operate.
- They operate any valve from the floor.
- They save time and money.
- The first cost is the only cost (no maintenance).
- They are packed completely assembled (one to a carton), with easy-to-follow instructions.
- A hot-galvanized rust proof chain is available for all sizes.

Babbitt Adjustable Sprocket Rims with Chain Guide are carried in stock by most mill supply houses. Just phone your mill supply salesman, or contact us direct.

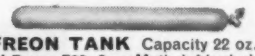
Babbitt STEAM SPECIALTY CO.
6 BABBITT SQUARE, NEW BEDFORD, MASS., U.S.A.

FLUID & GAS PRESSURE TANKS
STAINLESS & CARBON STEEL TANKS
(GOVERNMENT SURPLUS BARGAINS)
Steel tanks for the handling, storage and transportation of gases, beverages, fuels, hydraulic fluids and other liquids. Stainless steel tanks for corrosive acids and gases.

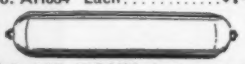
J-1 PRESSURE TANK Stainless steel, surplus aircraft oxygen tank. 48" long, 24" dia. Rated for 400 P.S.I. working pressure, 18,000 cu. in. vol., 77.9 gal. capacity. ¼" pipe thread fitting at each end. New condition. Shipping weight 247 lbs. F.O.B. Chicago.
No. AH832 ..... $99.50

G-1 TANK Stainless steel. Capacity 2100 cu. in. (9 gals.) 450 P.S.I. ¼" pipe thread port at each end. 24" long, 12" dia. Shipping weight 19 lbs. F.O.B. Chicago. (Two for $27.00.)
No. AH63 Each $14.95

NON-SHATTERABLE CO_2 CYLINDER This type of pressure bottle was used by the Armed Forces for inflating life rafts. 18¼" long, 3¾" dia. Has ½" pipe thread opening at one end. Capacity 2.98 lbs. of CO_2—at 1800 P.S.I. Shipping weight 10 lbs. F.O.B. Chicago.
No. AH303 ..... $2.50



FREON TANK Capacity 22 oz. of Freon F22, 6 cc Methyl Alcohol. 18¼" long, 2" dia. ¾" pipe thread opening at one end. Equipped with brass valve. Shipping weight 3 lbs. F.O.B. Chicago. (Six for $8.00).
No. AH834 Each $1.50



D-2 AIR TANK Carbon steel. Capacity 500 cu. in. (approx. 2 gals.) 450 P.S.I. ¼" pipe thread port at each end. 24" long, 6" dia. Postpaid. (Two for $8.50).
No. AH391 Each $4.95

CORNELIUS HIGH PRESSURE (1500-2000 P.S.I.) AIR COMPRESSOR Three cylinder, 3-stage compressor, complete with 27 volt, D.C. 20 amp. motor, with fan. Rated 1500 P.S.I. continuous duty, 2000 P.S.I. intermittent. Pressure switch in base. As released by Air Force, in used, serviceable condition. Covered by our 30 day GUARANTEE. 11½" long, 7" high, 9" wide. Shipping weight 12 lbs. F.O.B. Chicago. Limited quantity.
No. AH549 ..... $35.00

Write today for FREE CATALOG of other EQUIPMENT BARGAINS !

GROBAN SUPPLY COMPANY
1139 SOUTH WABASH AVE., DEPT. AH-3, CHICAGO 5, ILL., WEbster 9-3793

FLY DELTA to the CONVENTION

American Petroleum Institute, Division of Refining

HOUSTON TEXAS

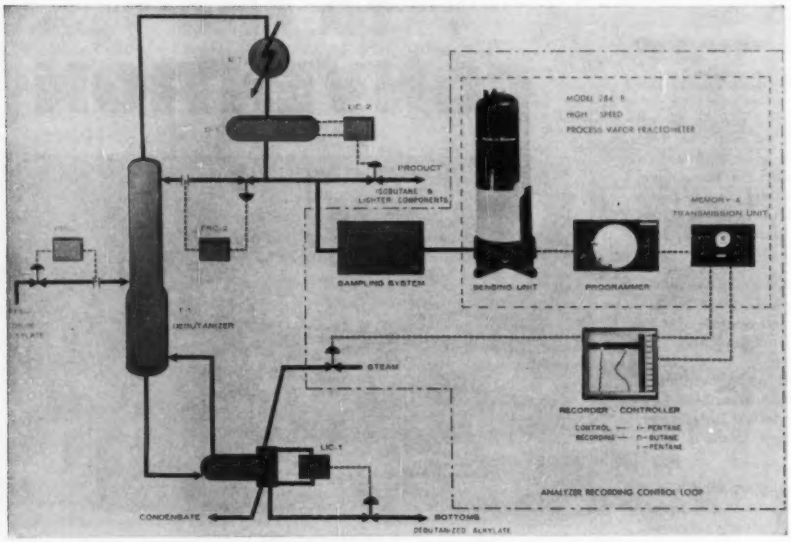
May 8-11, 1961

You fly the finest when you fly Delta, the air line that serves Houston with Convair 880's, world's fastest jetliners. Also dependable Douglas DC-6 or DC-7 deluxe and coach flights. For reservations, call your nearest Delta office, or see your Travel Agent.

DELTA
the air line with the BIG JETS

New Equipment & Literature...

as selected by Frank L. Evans, Jr., Maintenance & Design Editor



System incorporates sensing unit with reading controller.

Closed-Loop Process Control With Chromatographic System

Controller contains programer and memory and transmission unit

The new Model 284-B process vapor fractometer is designed for use on multi-component process streams. Typical uses of the instrument include monitoring and closed-loop control of: distillation tower fractionators; alklation reactors; hydrogen sulfide to sulfur dioxide ratio in sulfur recovery plants; and oxygen and carbon monoxide in regenerators of catalytic cracking plants. The instrument delivers control signals of 0 to 4 milliamperes, 0 to 50 volts, proportional to the concentrations of measured components. When used with a milliampere to psi transducer, it is suitable for duty in pneumatic control systems.

The system incorporates a sensing unit and a multi-component peak reading controller (see diagram). A high-speed pneumatic valve in the sensing unit introduces gas samples into the chromatographic column in less than one second. The sample passes through one or more columns, which separate it into its components. The components are eluted into a special detecting and measuring unit. Carrier gas flow rate and analyzer temperature are both closely controlled to assure stable, reproducible results.

All sensing unit functions are controlled and actuated by a programer, which is a component of the peak reading controller. The other major part of the controller is a memory and transmission unit. This unit performs two basic functions. It receives, selects and stores only the peak values of the component signals transmitted and it later amplifies and transmits segregated peak values separately, according to commands from the programer. The transmitted signals are available for both control and data recording purposes. Perkin-Elmer Corp.

Circle E1 on green card, last page

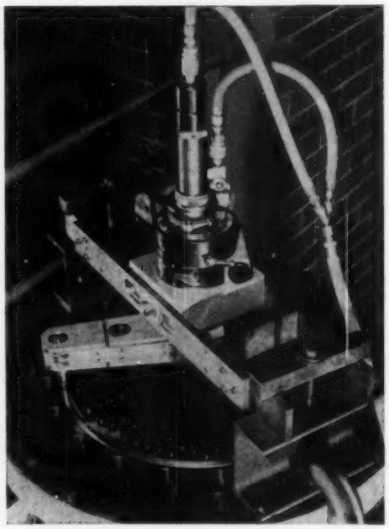
Portable Grinder Used For Precision Maintenance

A lightweight, portable grinding machine, developed to eliminate many problems normally associated with precision maintenance work, has handled a variety of grinding, machining and boring jobs in difficult spots which could not be reached with ordinary equipment.

The GIG can be taken to the machine to be repaired, and the work performed in place. In most instances, dismantling of the equipment is not necessary.

Among jobs on which the GIG has been used successfully are these: Remachining steam turbine control valve; rematching seats in high-pressure heater tube bundles, which normally would need to be dismantled and moved for repair; remachining heat exchanger head; remachining globe, check and safety valves in the line by removing bonnet.

Repair of the above high-pressure heater tube bundle was accomplished at the job site by the versatile GIG. The project required refacing the seat of the 22-inch diameter head and re-

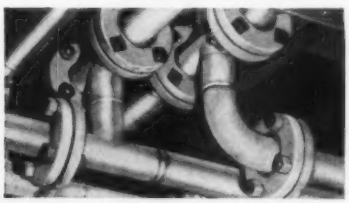


machining the gasket grooves in the heater tube seat. Conventional methods would have necessitated moving the cumbersome tube bundle to a large lathe or a complete retubing job, and the two flanges on the head

DON'T BE HANDICAPPED BY OUTDATED SPECIFICATIONS!

YOU CAN SAVE MONEY ON PROCESS PIPING SYSTEMS!

IMPROVED FITTINGS DESIGN AND NEW PIPING STANDARDS CUT COSTS!



The ultimate installed cost of corrosion-resistant process lines *can* be substantially reduced . . . where pipe line design specifications take full advantage of up-to-date developments in improved fittings design and new piping standards.

The most recent issue of the Code for Pressure Piping, ASA B31.3-1959, allows use of *light wall* Stainless Steel Schedules 5 and 10 pipe and fittings for critical process lines to a degree not possible with *outdated* specifications. The broader scope of pressure-temperature operating conditions included in this new code, permits computations utilizing these more economical wall thicknesses. This, plus a specification recognizing the efficiency of Speedline fittings, guarantees a soundly designed system at a *lower* installed cost.

Every Speedline fitting has built-in advantages that contribute to lower installation cost because they are designed especially for use with light wall Schedules 5 and 10 pipe. Speedline's extra length feature means butt joints are easier to align and easier to weld because you're always connecting "straight to straight". There's ample clearance to attach flanges to any or all ends of a Speedline fitting without fouling—by expanding or welding. Speedline aligning connectors assure sound socket-joining for both pipe and fittings. With Speedline—*one fitting* does it all. Review your process piping specifications to be sure they call for all of the cost savings possible with light wall pipe and modern Speedline fittings.

Speedline®

CORROSION-RESISTANT FITTINGS

STAINLESS STEEL • ALUMINUM • SPECIAL ALLOYS

100

A PRODUCT OF **HORACE T. POTTS COMPANY** • 566 E. ERIE AVENUE, PHILADELPHIA 34, PA.

For more data on advertised products, use Readers' Service Cards, last page.

Where control depends on measurement!
CON-O-PAK THERMOCOUPLES
FROM -300°F TO 4000° PLUS
The world's finest thermocouples. New process increases precision and temperature range. Exceeds all military and commercial specs. Con-O-Pak is used in aircraft, missiles, nucleonics, chemical processing.
Useful data? . . . Ask for "The Con-O-Pak Story."
CON-O-PAK
CONTINENTAL SENSING INC.
1950 N. Ruby St., Melrose Park, Illinois
FLEXIBLE AND SHEATHED THERMOCOUPLES • THERMOCOUPLE WIRE • HEATING ELEMENTS • CONNECTORS

WE WEAVE ACCURATE "WORKING OPENINGS"
IN WOVEN WIRE SCREEN AND WIRE CLOTH PRODUCTS
Whether you are grinding, sizing, scalping, dewatering or filtering it's the accuracy of the "working opening" that makes the difference in woven wire screen and wire cloth products. We pride ourselves in weaving accurate "working openings", an engineered screening surface to meet your specification.
First, the best metal or alloy is selected—hard enough to withstand the abrasive action—ductile enough not to break under stress. Next, the best wire diameter and crimp are determined. Then we weave wire screen or wire cloth around accurate "working openings" best suited for your screening application.
FREE! Write for bulletin 160 giving complete details and facilities.
THE CLEVELAND WIRE CLOTH & MFG. CO.
3571 EAST 78th STREET • CLEVELAND 5, OHIO

New Equipment . . .

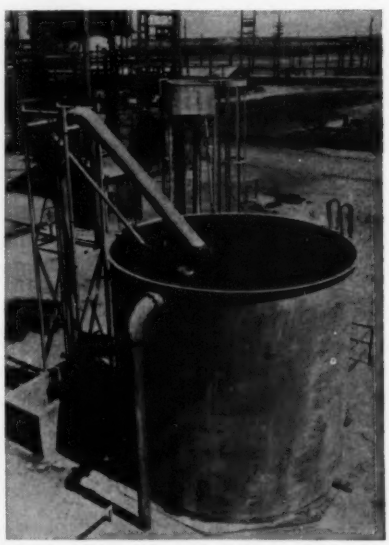
would have to be cut off so that it could be chucked up in a lathe. Use of the GIG saved an estimated $1,500 on the retubing job alone. Gilmore Industrial Grinders, Inc.

Circle E2 green card, last page

Cooling Water Silt Cut By Using Bypass Filter

A troublesome and costly problem, silt in cooling water, has been greatly reduced by Phillips Chemical Co. through the use of equipment comparatively new to cooling water systems.

The problem was this: the Cactus plant is located in the Texas Panhandle where there are frequently large quantities of dust in the atmosphere. This dirt entered Phillips' open recirculating water cooling system and deposited in piping



and heat exchange equipment. This in turn also promoted biological fouling and corrosion. The result of all of these conditions was poor heat transfer and high maintenance costs.

To lick this problem Phillips selected the automatic valveless gravity filter. Through this filter, Phillips bypasses approximately 1 percent of the total flow of water circulating through the tower. Constant filtering of this percentage, Phillips has found through spot analysis, reduces the silt burden to an acceptable point. In the first week of operation with the new filter, the concentration of suspended matter in the circulating water dropped from 2.0 ppm to 0.5 ppm, and has subsequently dropped to a point at which it is considered negligible.

The filter does not contribute in any way to operating costs. No extra labor is involved in operation or maintenance, and no pumps are needed because the filter works on the existing pressure head of the cooling system. Also, the filter system at Phillips operates without the need for addition of any coagulants to

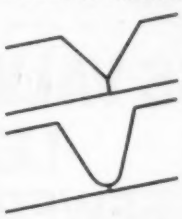
For more data on advertised products, use Readers' Service Cards, last page.

. . . cuts welding costs of fabricating process piping

FEATURES OF **FLOWLINE** FITTING WELDING ENDS ASSURE COST-SAVING PIPING CONSTRUCTION

SQUARE END . . . machine tool cut

CIRCULARITY AND TRUE WALL UNIFORMITY



MACHINE TOOL CUT BEVEL . . . NOT GROUND

We Make Corrosion-Resistant Welding Fittings— *nothing else!*

FINER FITTINGS THROUGH SPECIALIZATION

COST NO MORE THAN ORDINARY FITTINGS

The cost of corrosion-resistant welding fittings is normally only a *small part* of the welding costs of fabricating a piping system. For this reason it pays to use FLOWLINE Fittings.

FLOWLINE Fittings, like all reputable piping materials, are made to A.S.A. and M.S.S. Standards. But—this is only half the story. Due to our methods of production and inspection FLOWLINE Fittings are supplied much closer to nominal dimensions than to industry-standard permitted extremes.

This high dimensional accuracy simplifies alignment and permits constant welding speed to be maintained with uniform penetration. Better, faster connections can be made—resulting in welding cost reduction and sound construction.

For specific evidence of cost savings you can effect by using FLOWLINE Fittings write for Form I-92.

FLOWLINE Fittings are regularly produced of Stainless Steels 304, 304L, 316, 316L and 347, Aluminum, Monel and Nickel, sizes ½" through 24", Schedule 5S through XX Heavy.

FLOWLINE CORP.

World's Largest Manufacturer of Stainless Welding Fittings

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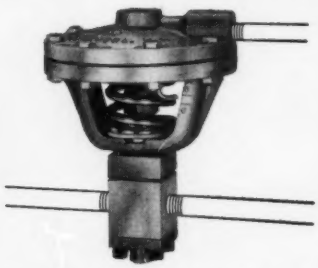
DENVER 4, 1328 Bannock Bldg. KEystone 4-4911—TWX, DN 372 — **TULSA,** Box 3325 TEmple 5-7575—TWX, TU 1234

F-11

G. W. DAHL • G. W. DAHL • G. W. DAHL • G. W. DAHL • G. W. DAHL

POSITIVE CONTROL FOR PROBLEM FLUIDS!



If suitable barstock material is available, any problem fluid can be throttled or provided with positive on-off control. Dahl BANTAM Control Valves, featuring barstock bodies, handle any chemical fluid except liquid metals like sodium and similar fluids where excessive temperature is a restriction.

BANTAM features include excellent flow characteristics, low hysteresis, and fast response. Offered in a wide selection of pneumatic operators and control positioners, standard models are rated at pressures up to 1000 psi at 450°F. Compactness, quality construction, and ruggedness also contribute to their virtually unlimited application versatility.

REQUEST Catalog B-1 for complete data on these versatile valves . . . for positive control of your problem fluids! G. W. Dahl Co., Inc., 85 Tupelo Street, Bristol, Rhode Island.

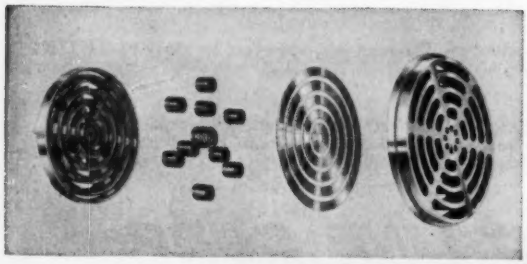
G. W. DAHL CO., INC.

SPECIALISTS IN COMPACT VALVES AND CONTROLS

G. W. DAHL • G. W. DAHL • G. W. DAHL • G. W. DAHL • G. W. DAHL

VOSS VALVES will mean LESS MAINTENANCE FEWER SHUTDOWNS for your COMPRESSORS

Voss Valves are made to specification, machined from solid stock (not cast)—using best alloy steels; for corrosion condition—stainless steels, such as 410, 18-8 or non-ferrous alloys—monel, inconel, etc. Plates are machined (not stamped) and ground for precise close tolerance fit; are dimensionally stable . . . ductile . . . resist fracture, high temperatures and corrosion . . . withstand fatigue. Springs of heavy rectangular sections and large diameters add to dependability and safety.



- **up to 40% more valve area**
- **minimum pressure loss**
- **higher efficiency**
- **less power consumption**
- **normal discharge temperature**
- **quiet, vibration-free**
- **utmost safety**
- **lower operating costs**

For detailed proposal send name, bore, stroke and speed of machine.

J. H. H. VOSS VALVES REG. U.S. PAT. OFF.

J. H. H. VOSS Co., Inc.
785 East 144th Street,
New York 54, N. Y.

New Equipment . . .

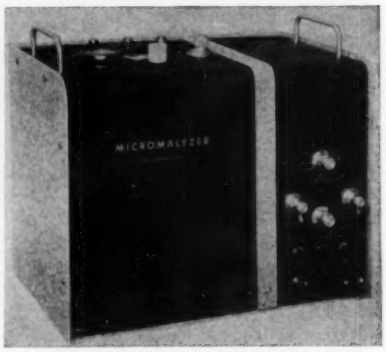
precipitate the suspended matter.

The installation at Phillips is 15 feet in diameter and approximately the same height. This tank is divided into three sections. Starting from the bottom there are the collector chamber, filter chamber (with false bottom), and the backwash storage area. Except for feed and discharge piping, that is it. No instruments, valves, or pumps. The Permutit Co.

Circle E3 green card, last page

Chromatograph Combines High Speed, Resolution

The Micromalyzer is a high-speed, high-resolution, high-sensitivity gas chromatograph. It combines the high speed and resolution of small-packed or capillary columns with the sensitivity of flame ionization detection. The complete analyzer including a 30-150° C thermostatically-



controlled oven and electrometer amplifier is housed in an attractive, vinyl-clad, aluminum cabinet 13¾ inches wide by 9 3/16 inches deep by 11 inches high.

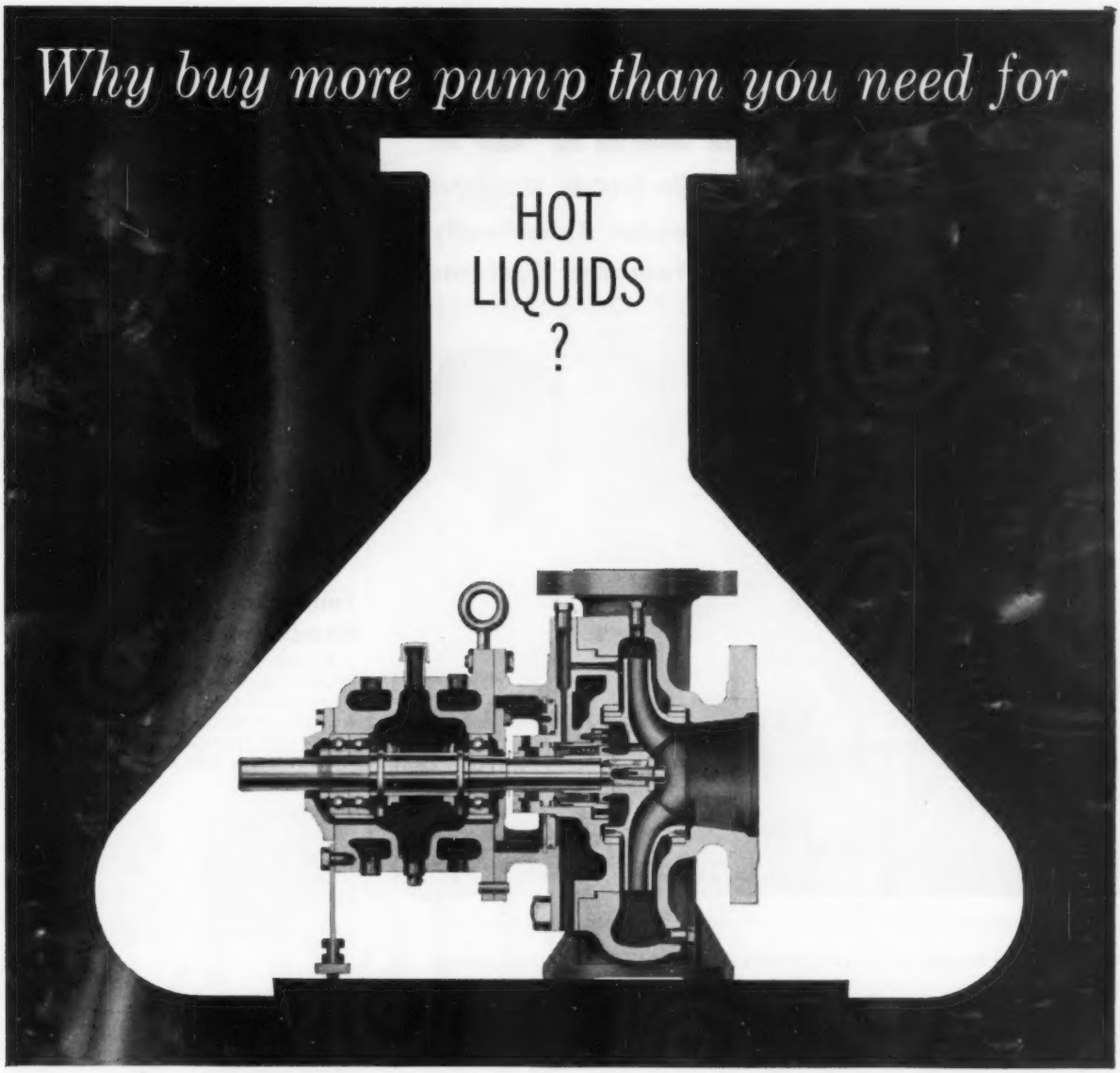
A simple but effective electrometer circuit provides full-scale sensitivities of 3×10^{-11} amperes with a 10 mv recorder. With well-stabilized hydrogen and carrier gas flows, this can be increased to 3×10^{-12} amperes by using a 1 mv recorder. Because of the large amplitude narrow base peaks, a recorder with a pen speed of not less than 1 second is required. An input attenuator of 1, 10, 100, 1,000 and 10,000 is supplemented by an output attenuator of 1, 2, 5, 10 and 20. The combination provides 17 ranges with a total attenuation of 200,000:1. The high sensitivity of the detector results in a background signal from stray hydrocarbons from such sources as the combustion air, carrier gas and especially from the column solvent. This signal is balanced out with a bucking circuit controlled by a multi-turn potentiometer on the panel. Hillikainen Instruments.

Circle E4 green card, last page

Sulfamic Acid Cleaning Increases 800 Percent

A new booklet gives recently developed scale dissolution rates for sulfamic

Why buy more pump than you need for



You take two big bites out of costs when you buy a Goulds Pump that *fits* your hot pumping service. You don't pay for more pump than you use—yet you have expensive pump features that keep maintenance costs down.

The Goulds Model 3775 handles liquids *as hot as 750°F*—and pressures up to 600 psi. Gives you all these features:

1. Cooled seal. Hot pumpage never touches the mechanical seal—because the seal is isolated in its chamber and surrounded by cool, dead-ended liquid. Coolant circulates through jacket to keep seal face to 250°, even when pumpage reaches 750°. A simple adjustment lets you change to external flush or heat exchanger cooling.

2. Cooled feet. Alignment stays true regardless of temperature variations because of centerline mounting and tapped inlet and outlet connections that permit circulation of cooling liquid.

3. Cooled bearings. Water-cooled housings maintain constant bearing temperature for longer life.

BACK PULL-OUT FOR EASY UPKEEP. A millwright alone can remove rotating parts without disturbing pipe connections or driver.

You get maximum economy in spare parts inventory, since all twelve sizes are built on the same bearing frame—one size bearings, shaft and seal for all pumps.

The husky Model 3775 is built to API specs, with a vertically split casing. Capacities go to 1200 gpm and heads to 500 feet.

Bulletin 724-1 gives you a more complete look at how Model 3775 can help you cut costs on hot pumping services. It contains specifications, construction details, pressure-temperature chart, and other helpful information. Write to Goulds Pumps, Inc., Dept. PR-31, Seneca Falls, N. Y.

GOULDS PUMPS

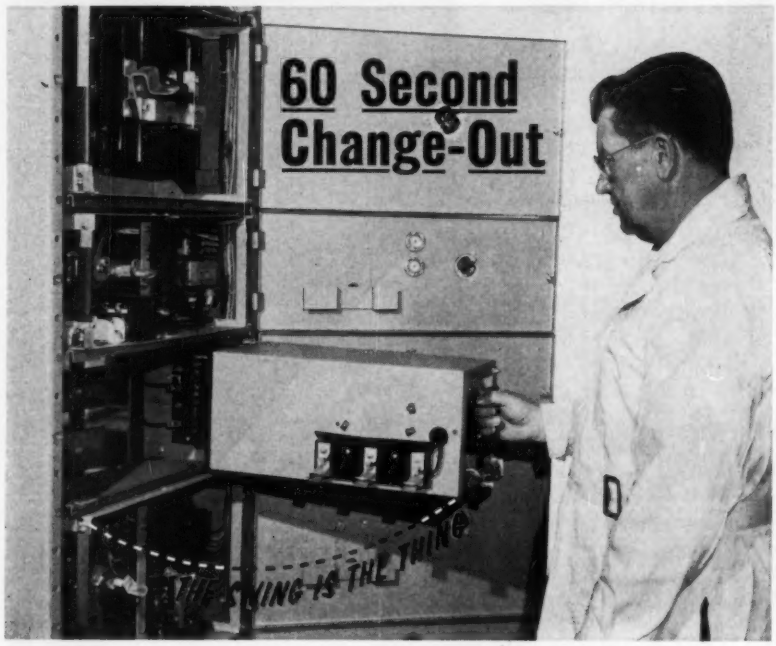
For more data on advertised products, use Readers' Service Cards, last page.

It's All NEW . . . In Concept In Application

Automatrol

► FROM NELSON

The First Motor Control Center Specifically Designed for use with Automated Systems



60-seconds or less is all the time required to change-out a starter or circuit breaker in the new Nelson AUTOMATROL motor control centers.

No tools, no specially trained personnel are required. You simply open the door, release the safety latch, swing the unit out and lift it off the pin hinges. You install the new unit just as easily. What could be more important when production is stopped?

This is only one of many new features found in Nelson AUTOMATROL motor control centers that are designed specifically for automation systems. For complete information write for Bulletin 2001 or call your local Nelson representative.

BIG ENOUGH TO PERFORM — SMALL ENOUGH TO CARE

NELSON *Electric* MANUFACTURING CO.
TULSA, OKLAHOMA

P. O. BOX 5385 NATIONAL 7-5530

New Equipment . . .

acid cleaners plus a diagram sheet showing simple equipment cleaning hookups.

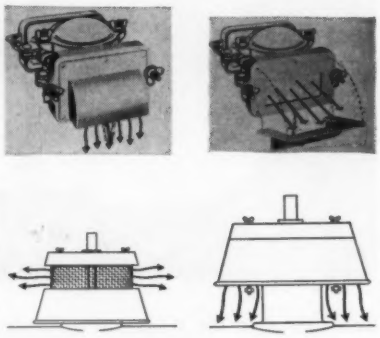
Use of sulfamic acid cleaners for in-place descaling of industrial equipment has increased about 800 percent in the last eight years, according to company data. Main advantages of the cleaners are their efficiency, ease of handling, and safety to personnel and equipment. Even at elevated temperatures, sulfamic solutions give off no fumes. In most cases sulfamic cleaners are used on a "do-it-yourself basis," without the expense of an outside cleaning contractor.

Other economies stem from reduced manpower requirements, lower freight and storage costs, and the fact that solutions can be strengthened and reused without the accelerated corrosion that results from the reuse of muriatic acid. E. I. du Pont de Nemours & Co., Inc.

Circle E5 green card, last page

Tank Vents Have Fuseable Hoods That Can Fall Free

A new line of operating and emergency vents which ensure horizontal discharge of ignited flammable liquid vapors and prevent localized flame impingement on the tank structure, incorporate weatherhoods which fuse and fall free of the



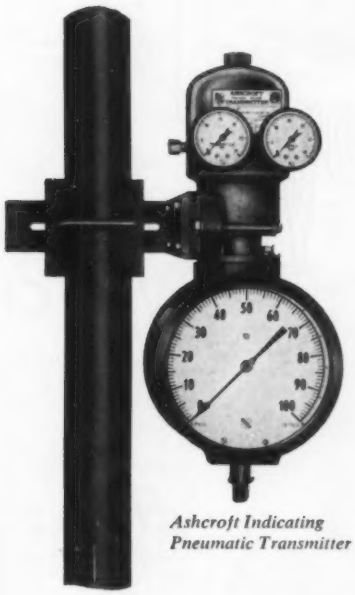
vent outlet if escaping vapors are ignited. Under normal (no-fire) conditions, the weatherhoods provide maximum protection of the tank's contents against rain, snow, air-borne contaminants, dirt, etc., because their opening is downward at an angle below the horizontal.

The Series 7800 emergency vents, which normally discharge vapors downward, are now also available with fall-away weatherhoods. The weatherhood is made in two sections which are held together with a heat-sensitive alloy. The parting line of the two sections is at the top of the weatherhood. As in the operating vent, fire at the emergency vent fuses the alloy securing the deep bottom section, causing it to drop free, thus changing the discharge direction of the vent. The Protectoseal Co.

Circle E6 green card, last page

signal

ASHCROFT PNEUMATIC TRANSMITTERS give you a true primary and transmitted signal for indication or control



Ashcroft Indicating Pneumatic Transmitter

action

Now—detect with precision accuracy the slightest change in primary pressure or temperature. Transmit this signal quickly to your indicators or controllers. Ashcroft Pneumatic Transmitters achieve these results for you at the lowest initial and operating costs.

Full-range, solid-front indicating and totally accessible nonindicating transmitters eliminate the need for costly high pressure lines, yet permit complete monitoring of process conditions in remote areas.

Narrow-span Ashcroft Transmitters are expressly designed with highest sensitivity and repeatability for the most accurate primary signal feed to controllers. You get better control and purer, lower-cost final products.

Only in Ashcroft Pneumatic Transmitters can you get the wide choice of Ashcroft Duragauge Bourdon tubes or American mercury or gas-actuated systems for sensing pressure or temperature conditions. You also get a time-proven, obstruction-proof, force-balance, nonbleed relay for economical, maintenance-free 3-15 psi or 3-27 psi signal transmission.

Write for factful Bulletins 360 and 361 or ask your nearby Ashcroft Distributor to help you select the right transmitters and receiver gauges for your specific requirements.

MAXWELL MANNING M&M & MOORE INC. TRADE MARK

ASHCROFT PNEUMATIC TRANSMITTERS

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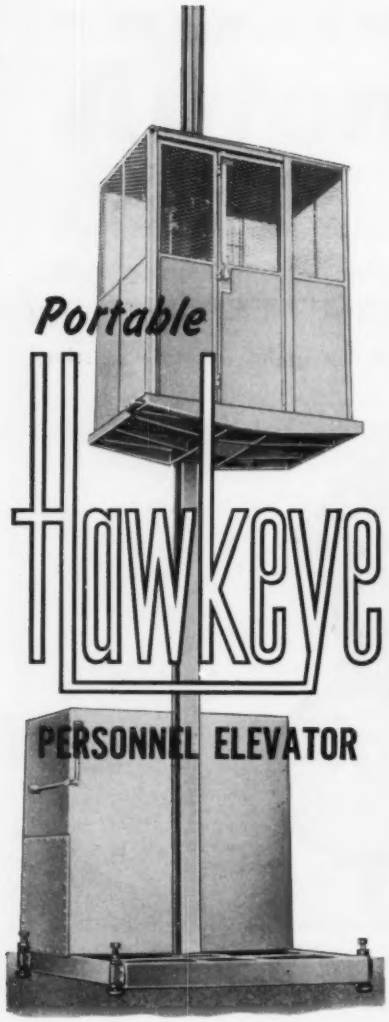

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for Men and Materials

Now you can have all the time-saving, labor-saving convenience of an elevator PLUS portability and low cost! The Hawkeye moves men and materials safely and surely to the top during construction or in permanent installations for operation and maintenance of production equipment. Your own men can move the portable model Hawkeye to its next point of need quickly and easily. Write today for complete information on the savings and safety that will be yours with Hawkeye!

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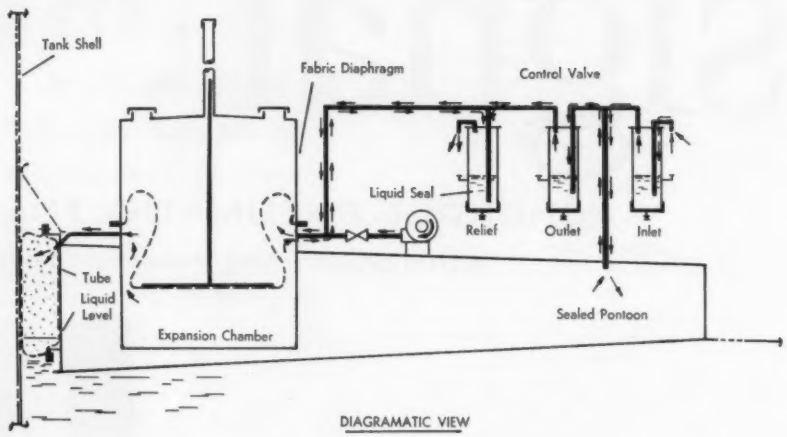
New Equipment . . .



DIAGRAMATIC VIEW

Floating Roof Seal Breathes With Change in Temperature

A pressure seal is an air-inflated, toroidal ring of coated fabric installed in the annular space between a floating roof and the shell of a tank. A floating roof seal, in order to be effective in eliminating losses, must always be in contact with the tank shell. The gap between the roof and the shell may vary from 4 to 12 inches, depending upon variations in the wall of the tank caused by riveted seams, out-of-roundness or shifting of the tank foundation.

The pressure seal, in its free shape, has a circular cross-section 16 to 18 inches in diameter; this allows ample contact with the tank shell even though the gap may be at its maximum distance of about 12 inches.

The pressure seal has the unique advantage of a special mechanism which provides continuously uniform pressure. Being inflated with air, the seal is subject to pressure variations caused by atmospheric pressure and temperature changes.

An expansion chamber is used to keep the pressure constant. It has approximately 20 percent of the capacity of the tube and is fitted with a diaphragm of impregnated fabric highly impervious to air. Its diaphragm is controlled by a guided flat plate which maintains a constant pressure throughout its vertical travel. It is connected directly to the seal so that any temperature variation simply causes the diaphragm to move up or down.

The primary concern of an owner-operator is the amount of attention required to maintain pressure. To make the pressure seal operative without attention, a specially designed control valve is provided which automatically adds air to the tube from a sealed pontoon of the roof. The sealed pontoon will tend to breathe with the temperature variations. It will "exhale" whenever the temperature increases and will "inhale" whenever the temperature decreases, the depth of breathing depending upon the control valve settings. Graver Tank & Mfg. Co.

Circle E7 green card, last page

16-Page Bulletin Covers Corrosion-Resistant Valves

A 16-page bulletin describes and illustrates the company's line of corrosion-resistant valves.

In addition to cross-section illustrations of the valves and adaptable features, with specifications for each, the bulletin summarizes the types of alloys in which each valve is available from stock, as regularly manufactured, or on special order.

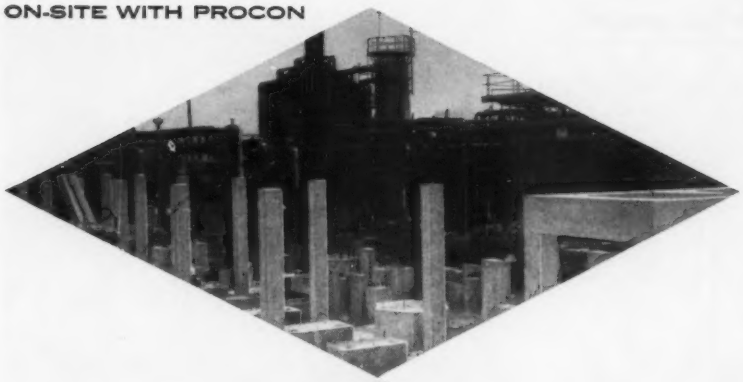
Complete engineering specifications of corrosion-resistant valves and a listing of alloy materials, with chemical composition ranges and minimum mechanical properties are particularly valuable sections in the bulletin. Alloy Steel Products Co.

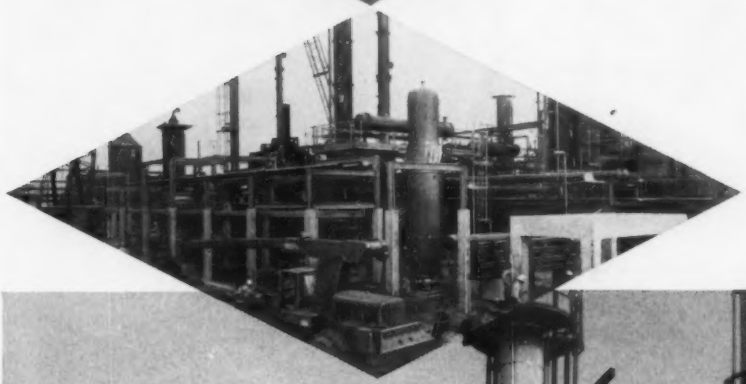
Circle E8 green card, last page

Barge Unloading Assembly Cuts Labor Costs

The Wheaton 6 and 8-inch rigid barge unloading assembly introduces new economies to the work, through a saving in labor. Only one man is required to operate the equipment, whereas in handling hose several men are needed. The tubes have 43-foot reaches, and the as-

ON-SITE WITH PROCON



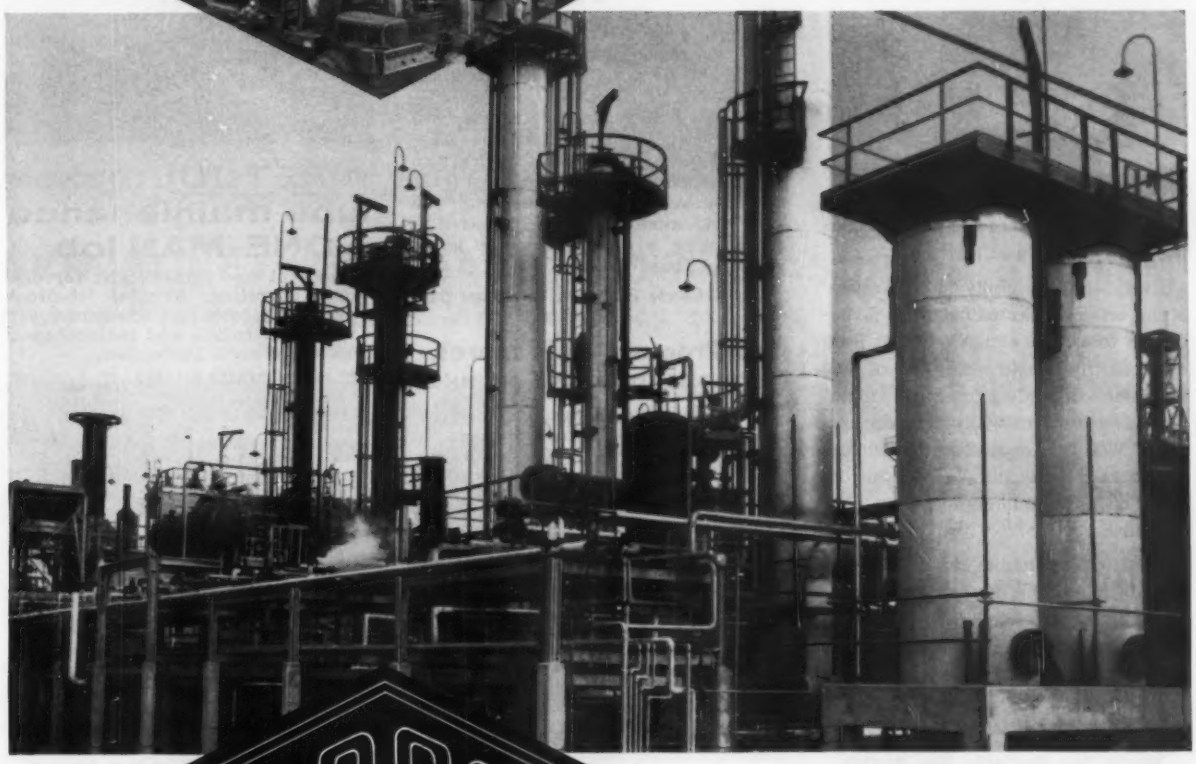


Procon-built Hydeal unit on-stream in 95 days!

Building a complicated process unit from the ground up requires the skillful coordination of a multitude of design, engineering, procurement and construction details.

It takes plenty of work, but most of all it takes time. Procon needed just 95 days from groundbreaking to on-stream acceptance of this Hydeal™ unit built for Signal Oil & Gas Company, in Houston, Texas. This highly efficient Hydeal unit produces 1,000 barrels-per-day of high quality benzene from a toluene charge. Signal markets the benzene direct to users in the Southwest.

New plant construction, expansion or modernization, whatever the requirement, you can trust the entire job . . . safely to PROCON.



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FOR PLUS SERVICE

SERV-RITE drilled protecting wells are made in types, lengths, and of alloys to meet any temperature and pressure condition in vessels and flow lines.

Every well is carefully made to assure a plus service. Selected bar stock is machined to within accurate limits. Bore concentricity is held within 5% of wall thickness, depending on well length. They are tested to withstand pressures up to 3000 psi., depending on the wall thickness. Exterior surface has a mirror-like finish for minimum resistance to flow in lines.

Complete assemblies can also be furnished with suitable thermocouple, head, flange, fittings, etc.

Give SERV-RITE a trial on your next drilled well requirements. There is none better.

Write for Bulletin No. 2000
for specifications, size, and ordering information on SERV-RITE drilled wells.

CLAUD S. GORDON CO.
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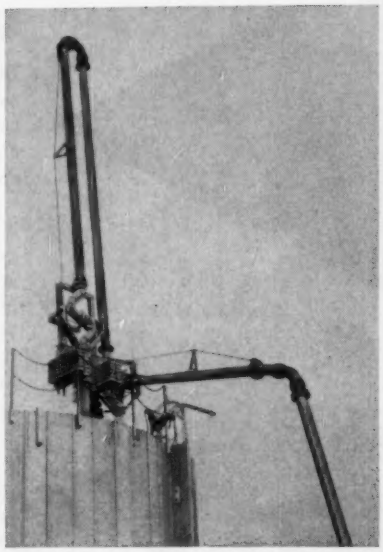
New Equipment . . .



sembly provides complete flexibility for connection to the barge mainifold.

This new barge unloader is also conducive to greater safety, as it eliminates the use of derricks, hoisting hoses and costly stairs.

The assembly has horizontal and vertical-base swing joints, made of high-pressure, flame-hardened steel with dual ball bearing raceways and enlarged packing chamber. Each unloader has two long, rigid, aluminum tubes supported by double-plane aluminum swing joints. Wheaton Brass Works.

Circle E9 green card, last page

Data Process Unit Prepares Magnetic Tape for Computer

A mobile, low-cost data handling system, which will eliminate the need for complex installations, is expected to con-

siderably reduce industrial data handling costs, and provide a vital new capability to many companies.

The system called Radac I, will collect critical data on speeds, fuel flow, temperatures, pressures and many other variables that must be measured during processing and production. Moreover, Radac I will itself process and prepare this information for direct entry into most common computers.

Normally, raw test data must traverse

AIRETOOL makes tube maintenance a ONE-MAN job

Compact and lightweight for one man operation, Airetool job-fitted pneumatic tools and accessories cut tube fabrication and maintenance costs and boost production.

CC-475 CONDENSER CLEANER
Powerful Airetool unit for fast, efficient removal of tough tube deposits. Built-in flushing system cools cutting head and washes out debris and scale.

AIRETROL
Positive, automatic tube expansion control. Accurate to within .001 inch. Quickly and easily pre-set. One man rolls up to 720 tubes an hour.

INTERNAL TUBE CUTTERS
Air-powered, compact and lightweight for use with precision cutting tools. Positive feed control governs rate of cut, eliminates gouging, etc.

Airetool also makes brush head cleaners, cleaning heads and motors for straight and curved tubes, as well as a full line of air operated production tools and grinders. For complete details or in-plant demonstration, write:

Branch Offices: New York, Chicago, Tulsa, Philadelphia, Houston, Baton Rouge
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AIRETOOL
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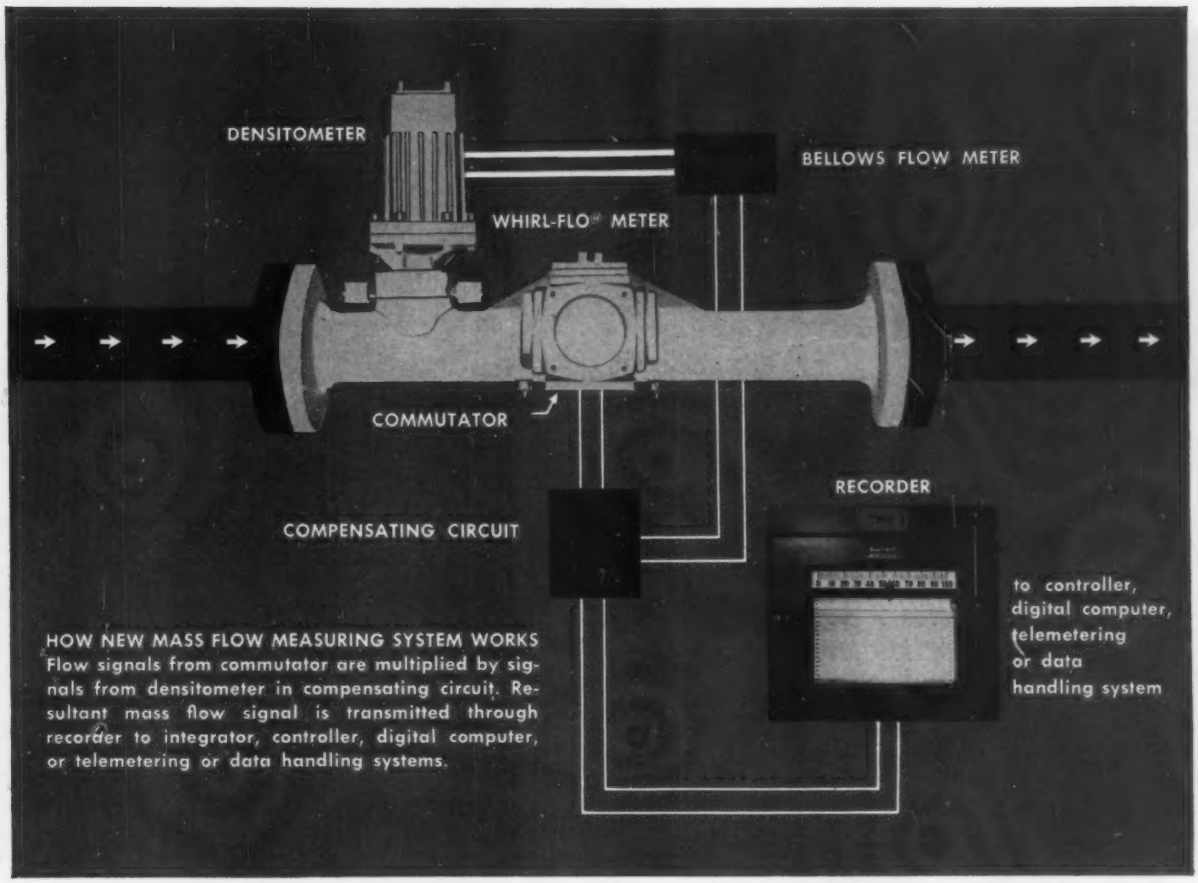
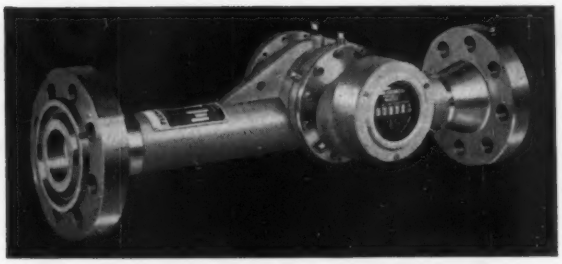

DENSITOMETER
BELLOWS FLOW METER
WHIRL-FLO® METER
COMMUTATOR
RECORDER
COMPENSATING CIRCUIT
to controller, digital computer, telemetering or data handling system
HOW NEW MASS FLOW MEASURING SYSTEM WORKS
Flow signals from commutator are multiplied by signals from densitometer in compensating circuit. Resultant mass flow signal is transmitted through recorder to integrator, controller, digital computer, or telemetering or data handling systems.

NEW HONEYWELL MASS FLOW MEASURING SYSTEM

meters liquids and gases with accuracy of ±½%



Here's the system that delivers *accurate, automatic, and continuous mass flow measurements* of liquids and gases for the most demanding process control, accounting, and custody transfer applications.

By using the highly accurate Whirl-Flo® Meter as the primary element, Honeywell makes available a fully compensated mass flow measuring system that delivers linear accuracies of ± ½% under most operating conditions regardless of changes in temperature, pressure, composition, or compressibility of the liquids or gases being metered. All the primary and compensating elements are built right into the system. You get a mass flow measuring system that's custom made to suit your specific application.

This new mass flow system can be linked easily to telemetering and remote control systems, data handling, and process computers . . . can meter a wide variety of fluids—water, air, propane, butane, natural gas, gasoline, no. 2 fuel oil, ammonia, ethylene, and even some slurries. The flow meter body itself is available in standard sizes from 2 to 16 inches.

Get complete details from your nearby Honeywell field engineer. Call him today . . . he's as near as your phone. MINNEAPOLIS-HONEYWELL, Wayne and Windrim Avenues, Philadelphia 44, Pa. In Canada, Honeywell Controls, Ltd., Toronto 17.

Honeywell

First in Control

SINCE 1885

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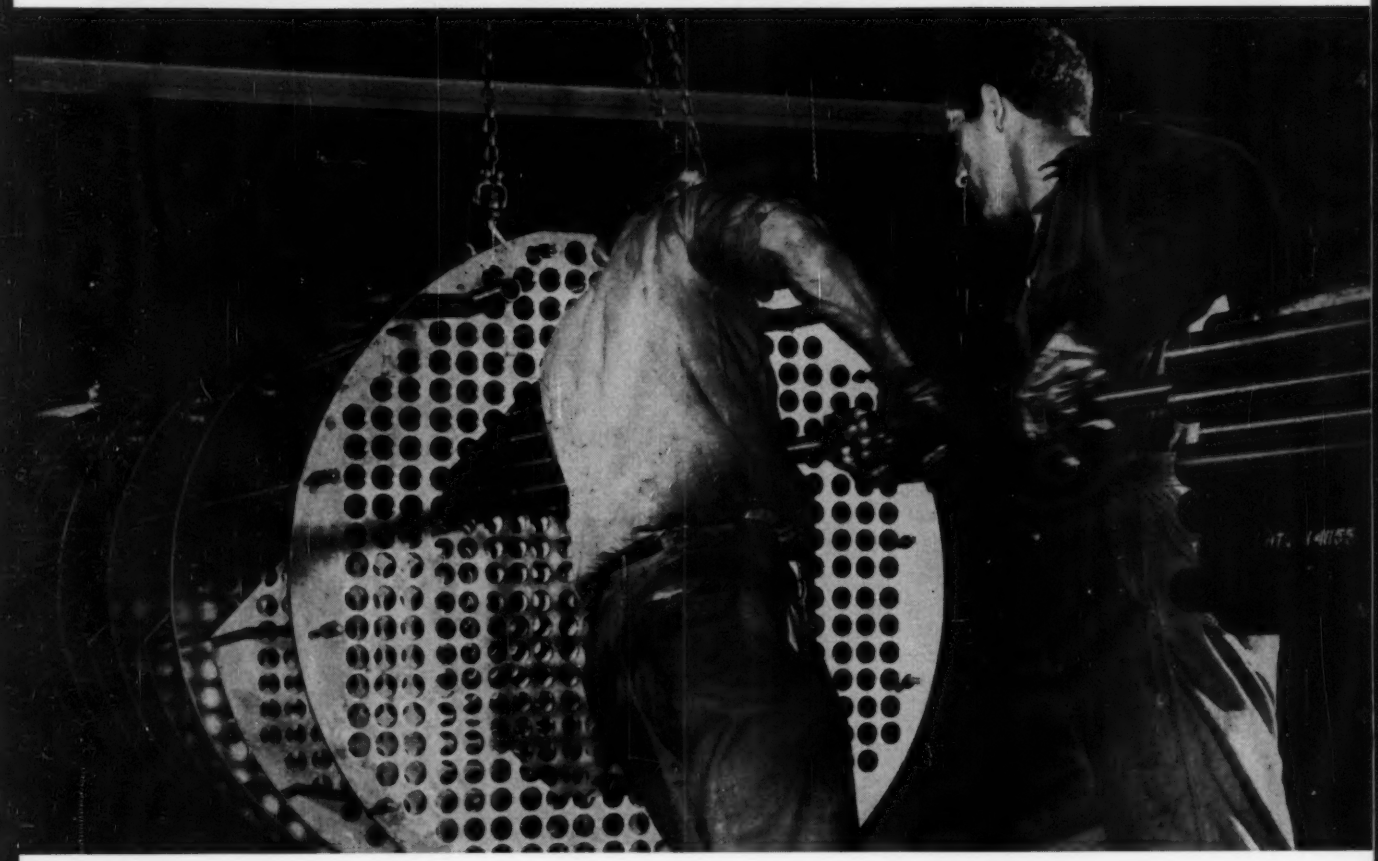

More than a mile of ELECTRUNITE tubing goes into this heat exchanger

FARROWTEST PRE-PROVES EVERY INCH

FARROWTEST REJECT TABLE

Wall Thickness (B.W. Gage)	Minor Dimension of Defect (Length or Depth)	Defective Area (Length, Depth Plane)
20	0.006 IN.	0.0025 Square Inches
18	0.006 IN.	0.003 Square Inches
16	12.5% of Wall	0.003 Square Inches
14 and 13	12.5% of Wall	0.004 Square Inches
12 and Heavier	12.5% of Wall	0.005 Square Inches

FARROWTEST detects and rejects not only tubing containing defects which completely penetrate the wall; but also tubing with defects equal to, or greater than, those shown in this table. For irregular defect shapes, a tube with defect area equal to or greater than shown above is rejectable. Where required, sensitivity of FARROWTEST equipment can be calibrated to reject defects of lesser specified area than shown in table, at extra cost.

Deep in the heart of a heating—or cooling—system there is no room for error of any sort .That's why every inch of ELECTRUNITE® can be FARROWTESTED®, the ultimate in nondestructive production line testing.

FARROWTEST probes the entire tube wall, rejecting minute defects too small to be detected by ordinary pressure methods.

FARROWTEST is offered by Republic as an alternative to other less positive tests at no increase in cost. Carbon Heat Exchanger Tubes are produced to ASTM specification A-214; Stainless Tubes to A-249. Both specifications include nondestructive clauses permitting eddy-current testing —FARROWTEST.

There can be no compromise in heat exchanger tubing. Highest quality is a must. Specify Republic ELECTRUNITE—exclusively FARROWTESTED for your protection. For complete information, call your Republic representative. Or, write direct.

WHERE CORROSION IS A PROBLEM, specify Republic ELECTRUNITE Stainless Steel Tubing. Manufactured to the same strict tolerances as all Republic Heat Exchanger Tubing, stainless rolls in easily, provides high resistance to chemical action, protects your product.

HIGH STRENGTH REPUBLIC ALLOY STUDS eliminate danger of creep, stretch, or fatigue-failure in demanding applications. Precision-cut threads insure that nuts tighten smoothly, back off easily. Send coupon for booklet.

REPUBLIC HEAVY DUTY DRUMS are produced in a full range of 55- and 30-gallon sizes. You can select the exact combinations of size, gage, head construction, hoop, threaded opening, and protective finish to meet your specific requirements. Write for full information.

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INSTRUMENT
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GAS ANALYSIS INSTRUMENTS

Continuous and Portable units

✓ PARAMAGNETIC OXYGEN MEASUREMENT

Detects oxygen content of gases. Simple non-electronic circuit. Fast response — 95% reading in 15 seconds. Ranges from 0-5% O_2 to 0-100% O_2. EXPLOSIONPROOF CONSTRUCTION AVAILABLE.

✓ PARTS-PER-MILLION GAS DETECTION

Measurement of P.P.M. gas concentration. Used in air pollution studies, contaminant control, detection of toxic gases and vapors. Compact units for field surveys as well as universal mounting cabinets and self-standing cubicles.

✓ COMBUSTIBLE GAS ANALYZERS

Complete diversified line of systems for detection of combustible gases and vapors in work areas; litho and coating oven atmosphere control; etc. Control of combustibles in inert gas streams.

✓ THERMAL CONDUCTIVITY ANALYZERS

Measurement of concentration to one gas component in a mixture of gases, utilizing sensitive filaments as the detector. Applicable for determination of: H_2 in O_2. N_2 mixtures; Argon in air; hydrogen purity; CO_2 in flue gas, etc.

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A Division of Davis Emergency Equipment Co., Inc.
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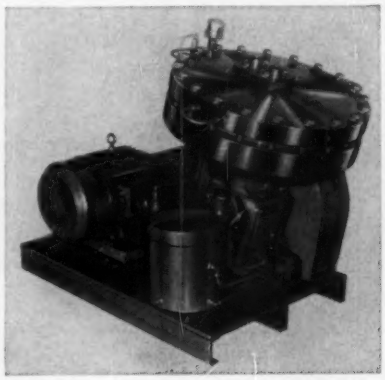
New Equipment . . .

a chain of large, expensive data processing systems before it is in the proper format for computer entry and analysis by scientists and engineers. The Radac I system eliminates the need for such complex equipment. It economically prepares specialized information on magnetic tape in formats for direct use with the IBM 650, 704, and 1260 systems, as well as the large IBM 7090 and other installations. Radiation, Inc.

Circle E10 green card, last page

Compressor Designed for Hydrogenation Experiments

A line of gas compressors has been designed to recycle, meter, and compress gases for operation with absolute freedom from contamination. Called Pulsafeeder diaphragm compressors, the units will recycle gases at pressures up to 5,000 psig, will meter with reproducible accuracy dependent on the varying intake



and the discharge pressure, and will compress gases from atmosphere with better than a 10-1 compression ratio. The units have been developed for oil refinery research, experimental work in hydrogenation, and chemical manufacturers.

The basic compressor line consists of three models. Model G-1 has a maximum capacity of 1.25 standard cubic feet per minute; model G-2 with capacity of 3.86 standard cubic feet per minute; and model G-3 with 10.3 standard cubic feet per minute. Smaller piston sizes with high pressure heads for each model to handle recycle applications are also suitable for stage compression. Efficiencies for all three models is approximately 50 percent at a 7:1 compression ratio. Process Equipment Div., Lapp Insulator Co.

Circle E11 green card, last page

24-Page Bulletin Gives Pipe Press-Temp Ratings

A new 24-page bulletin, TB1-1960, has been completed by the Engineering Standards Committee and is now available in printed form upon request. First single copy is free, additional copies $2 each. The bulletin lists in tabular form,

Some Reasons Why
DURA MECHANICAL SEAL
is the Best to Buy

DURA SEAL is backed by 25 years of experience in the mechanical sealing field.

DURA SEAL means successful sealing of corrosive, volatile or abrasive conditions.

DURA SEAL meets the widest range of pressures, temperatures and liquids.

DURA SEAL is easy to install — application can be made on your present equipment.

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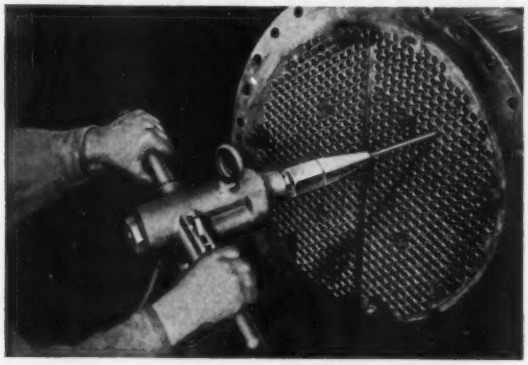
KNOCK OUT SCALE WITH SUPER-POWERED WILSON TUBE CLEANERS

Are your heat exchanger tubes completely fouled with scale buildup? Or, are you looking for that last vital inch of heat transfer efficiency? In either case, efficient, hard-working Wilson Tube Cleaners are the answer.



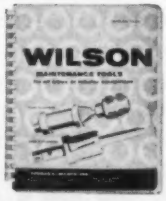
For heavy duty service, for example, use Wilson air driven Model TP 301 shown above. This super-powerful, 15 lb, light weight, scavenger-type tube cleaner drills and simultaneously flushes out deposits. It is suitable for vertical or horizontal use in straight tubes ⅜" ID to 2⅞" ID and up to 40' long. Cleans rapidly and thoroughly, operating at high speed at 90 psi. Can run on pressure as low as 50 psi. Other Wilson Cleaners are available for every tube size.

WILSON SUPER-DUTY CARBIDE BITS

TYPE M BIT
An inserted two-lip Helix type for general use. 1½" to 1 19/32" bit OD.

TYPE K BIT
A two-lip Helix type with adaptor for general use. 1¼" to 2¾" bit OD.

TUBE EXPANDERS— Wilson Models 41 and 44 Self-Feeding Tube Expanders are modern tube expanders for the *precision rolling* of condenser and heat exchanger tubes into heavy tube sheets. Ball Bearing Collar Type ½" OD to 2½" OD • **Write for your free copy of Wilson Catalog 77-88. It's a mine of information on tube cleaning and tube expanding problems.**



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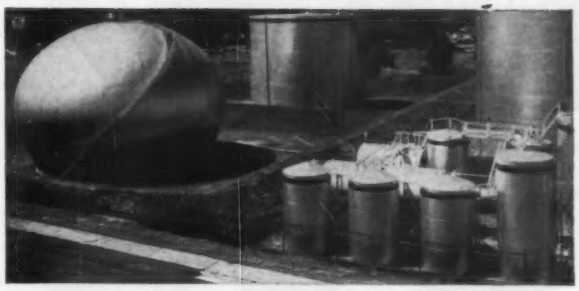
BETTER TOOLS FOR BETTER WORK



with UROX® WEED KILLER

One Application Gives 8 to 18 Month Control!

Here's the weed killer you can *positively depend on* to wipe out weeds and brush faster, easier, at lower cost and for a longer time than you ever thought possible. Urox weed killer effectively handles weed killing jobs along pipelines, on tank farms, around refineries and pumping stations, where weeds and brush are a constant fire hazard. In all these places, *just one application of Urox weed killer will remain effective for as long as 8 to 18 months!*

Longer lasting! Saves time and money! Urox weed killer has a cumulative effect on weeds and brush. Its herbicidal action can thus be extended from one year to the next with light booster doses. As smaller amounts are used over a period of time, you realize substantial savings.

Easy to use! *Liquid Urox* weed killer is ideal for spraying large overgrown areas. It won't clog spray nozzles or strainers! Won't precipitate out in the tank! Stays in solution perfectly! *Granular Urox* weed killer is the convenient inexpensive way to treat small weed-infested areas. Can be applied easily with any mechanical or hand-operated spreader.

New Urab® weed killer kills deep-rooted brush and weed trees! If you have problems with tough, deep-rooted weeds, brush or weed trees, *New Urab Weed Killer* is just what you're looking for. Urab weed killer actually *penetrates soil* to kill deep roots. Does what no other herbicide can! Supplied in liquid and granular forms.

*Trademark of Allied Chemical Corporation

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GENERAL CHEMICAL DIVISION
40 Rector Street, New York 6, N. Y.

Weed Killer Dept. PR-31
GENERAL CHEMICAL DIVISION
Allied Chemical Corporation
40 Rector Street, New York 6, N. Y.

☐ Please send me more information about General Chemical's amazing new herbicides, Urox and Urab.

☐ Please have representative phone for appointment.

Name_____

Title_____

Company_____

Address_____

City_____ Zone_____ State_____

So SIMPLE that "Specials" are Likely to be Standard!

A sleeve, raised and lowered within a non-magnetic tube, attracts or releases an Alnico magnet attached to a mercury switch. Basically, this is Magnetrol

MAGNETROL

The World's Most Dependable

LIQUID LEVEL CONTROL

Because of the utter simplicity of Magnetrol's magnetic operating principle, standard models can be easily adapted to meet any special requirements for pressure, temperature or corrosive liquids . . . and usually at little extra cost. This Magnetrol versatility has solved all kinds of tough level control problems . . . and given our engineers wide application experience that can be invaluable to you.

Magnetrol is so simple that failure is all but impossible! Using only permanent, unfailing magnetic force for its operation, there's nothing to wear out . . . no diaphragms or bellows to stiffen and rupture . . . no electrodes to short or corrode . . . no packing to bind or leak. Magnetrol is practically maintenance-free! Magnetrol units are available for controlling level changes from .0025-in. to 150-ft. . . . with multi-stage switching when desired. Send coupon for full details.

MAGNETROL, Inc.

Send Coupon For Full Details

MAGNETROL, Inc., 5312 Belmont Road, Downers Grove, Illinois

Please send me catalog data and full information on Magnetrol Liquid Level Controls. 6

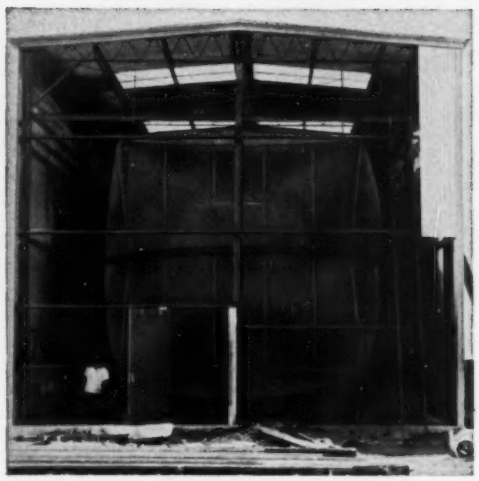
Name_____

Company_____

Address_____

City_____ Zone____ State_____

BIG SAVINGS WITH LOW-COST REEVES-VULCAN BREATHER BALLOONS



Stop vapor loss with this air-tight, self-contained, completely closed system.

Now—with a low-cost Breather Balloon installed in new or modified storage systems, you can capture the vapors that might otherwise be lost during the storage or transfer of volatile liquids. Reeves-Vulcan Breather Balloons require no skilled labor to install, no high priced housing . . . cost practically nothing to maintain.

Ultra-high strength neoprene-coated nylon gives these rugged balloons unusually long life. Every Breather Balloon installed is still in use, still returning profits. Make your storage tank a closed system . . . install Reeves-Vulcan Breather Balloons—the most efficient and most economical system of vapor conservation ever developed for low to medium storage volume.

For free, informative brochure, write to: Reeves Brothers, Inc., Vulcan Rubber Products Division, 1071 Avenue of the Americas, New York 18, New York.

REEVES VULCAN

Reeves Brothers, Inc., Vulcan Rubber Products Division
1071 Avenue of the Americas · New York 18, New York

pressure-temperature ratings of carbon steel, molybdenum, chrome-molybdenum and chromium silicon molybdenum alloys in all the standard sizes of seamless piping. Chemical requirements, in relation to the various types of seamless pipe and weight charts, are included for handy reference. The bulletin is the fifteenth in a series of technical bulletins and standards covering a wide variety of pipe recommendations and fabricating practices. The Pipe Fabrication Institute.

Circle E12 green card, last page

Non-Metallic Fan Blades Absorb High Stresses

Non-metallic fan blades of unique design for cooling tower fans up to 22 feet in diameter are now eliminating the corrosion problem in petrochemical plants

and oil refinieries. The adjustable-pitch, tapered blades are illustrated by 16-foot diameter fans used by Sinclair Refining Co., Houston.

To minimize blade cost and assure maximum performance, thin, shaped sheets of Micarta are bonded together and precut from material obtained in sizes that make the least waste. This material is a phenolic-impregnated, fabric-base laminated plastic. The blades "are not notch conscious" like metal, and can absorb vibration and other stresses far beyond those of normal service. Hartzell Propeller Fan Co.

Circle E13 green card, last page

Flame-Sprayed Coatings Repair Worn Parts Quickly

A new bulletin, "Industry Report No. 3, Petroleum," illustrates and describes how flame-sprayed coatings of a wide range of metals are used to repair and improve worn parts at high speed and low cost. A variety of parts are covered including valve plugs and seats, pump rods, plungers, impeller blades and shafts, polish rod liners, sucker rod couplings, tool holders, etc.

Also reviewed are the advantages of pure flame-sprayed zinc or aluminum coatings in the protection of equipment against atmospheric or salt spray corrosion for maintenance-free service measured in decades. Parts treated include heat exchangers, stacks, tracking towers, gasification tubes, etc. Metco, Inc.

Circle E14 green card, last page

34 Sizes Available In Centrifugal Pump Line

New sizes have been added to the company's Model 3405 line of single-stage, double-suction centrifugal pumps. Thirty-four sizes are now available to provide capacities from 100 to 6,400 gpm with heads up to 525 feet. A choice of grease or oil-lubricated bearings, wide degree of interchangeability of parts, availability in stainless steel and ductile iron, are among the many features of this highly popular group of pumps. Complete specifications, interchangeability chart, performance curves and dimensions are shown in a new bulletin. Goulds Pumps, Inc.

Circle E15 green card, last page

Glassed Pipe, Valves, Fittings Prevent Corrosion

A new 16-page bulletin describes glassed-metal pipe, valves and fittings.

The bulletin presents a short introductory paragraph on the need for glassed-metal pipe and accessories as a vital link in installations that require resistance to corrosion or contamination

DIAL THIS PUMP FOR THICK OR THIN

Vari-Flo changes capacity instantly

If you're moving a variety of liquids—or one liquid at changing temperatures—there's no need to use several pumps. One Blackmer Vari-Flo can solve your problem, save you time and money. With Vari-Flo, you just dial a low capacity for thick liquids, then gradually increase the rate as the liquid gets thinner. You can even reverse the flow without changing pump speed or direction! What's more, the Vari-Flo does all this with an ordinary, standard-speed motor. No complicated variable-speed drives are necessary. The secret is inside the pump. See how it works. See how it can solve your pumping problems. Write for Bulletin 600 today.

"liquid materials handling"® equipment

BLACKMER / vari-flo pumps

BLACKMER PUMP COMPANY, GRAND RAPIDS 9, MICHIGAN

Find your Blackmer Man under "Pumps" in the Yellow Pages

New Equipment . . .

of product. Separate sections are devoted to standard Glasteel pipe, non-adherence Glasteel pipe, expansion joints, F-C (field cut) Glasteel pipe, glassed ductile iron fittings, sight boxes, glassed outlet valves, pop safety valves, spray rinse valves and other standard items.

The bulletin contains cut-away drawings, and complete specifications and dimensions for all of the components discussed. The Pfaudler Co.

Circle E16 green card, last page

Distillate Treating Covered in Detail

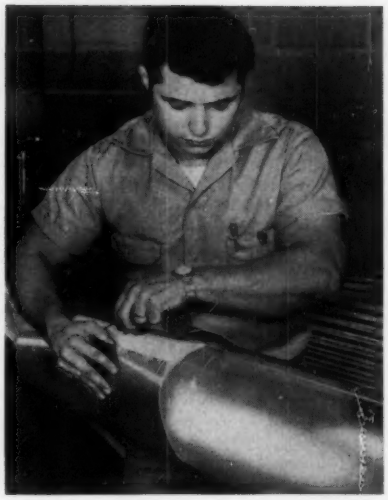
A new nine-page brochure on distillate treating for petroleum refiners gives a detailed description of the electrofining processes used to treat distillates and middle range oils.

Interspersed throughout the booklet are photographs, photomicrographs, drawings, charts, tables and diagrams to describe and explain the distillate treating processes. Petreco Div., Petrolite Corp.

Circle E17 green card, last page

Aluminum Jacketing Can Be Installed Overhead Cheaper

Now contractors and maintenance crews can aluminum sheath overhead



insulated lines without special tools and with less labor. A new Loc-Jac, Z-Crimp aluminum jacketing that can be installed by one man even on overhead lines is pre-cut and pre-rolled and ends the need for heavy cutters and rollers.

The natural tension of the rolled sections will hold the jacketing in place until secured. A Z-Crimp along one edge of the jacketing forms a water-tight seal with the opposing edge. Each section interlocks with adjoining sections to form a continuous seal.

Using Loc-Jac permits the insulator to stagger the insulation and sheathing joints. A 2-inch circumferential overlap of the jacketing provides for natural expansion without separating the joint. The interior surface is moisture-proofed by a 60-pound natural kraft paper with 10-pound polyethylene coating solidly bonded to the jacketing. Sections can be joined with pop rivets, screws or bands. Any type insulation may be used. Jacketing is pre-cut and rolled to pipe size and insulation thickness. Premetco.

Circle E18 green card, last page

Engineering Data Included In New Coupling Bulletin

Bulletin 4100 presents the company's complete line of torsionally resilient Steelflex couplings. New pages, additional coupling types, dimensions for larger sizes, and easier methods of selection are included. How the unique grid-groove coupling design protects connected machines against shock, vibration, and misalignment is explained and illustrated. Charts and tables, appearing throughout the bulletin, contain up-to-date engineering data. The Falk Corp.

Circle E19 green card, last page

Ball Valve Line Handles Practically Any Fluid

A new line of ball valves in combinations of metals, seats and seals to handle

MODEL 9B PYROTEST

The Most Versatile Portable Potentiometer Made

- **Checks any thermocouple-actuated instrument**
- **Guaranteed accuracy— ⅛ of 1%.**
- **9 interchangeable, direct-reading scales**

Pyrotest is the only portable potentiometer that can check any thermocouple-actuated indicator, controller, or recorder. It comes with 6 thermocouple scales and 3 MV scales—as easy to change as phonograph records. Scale length of over 4 feet, with high resolution to match. Pyrotest is so accurate, it's used as a standard in the lab . . . so versatile and rugged, it's used as an all-purpose tool everywhere in the plant. Only $315.00, fob Indianapolis. Write for free Bulletin 9-B.

TECHNIQUE

TECHNIQUE ASSOCIATES

A Division of Duncan Electric Co., Inc.

1413 CORNELL • INDIANAPOLIS 2, INDIANA

RIGGIO

Thermostatic Steam Traps

For Maximum Efficiency Choose From This Line of Riggio Thermostatic Steam Traps

For pressures from Vacuum to 200 lbs. Bronze Construction ½", ¾", 1"

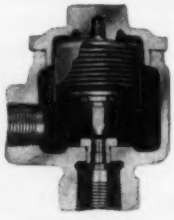
For pressures from Vacuum to 250 lbs. Semi-steel Construction ½", ¾", 1", 1¼", 1½", 2"

Simple

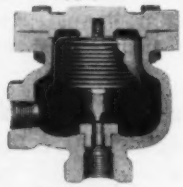
Rugged

Versatile

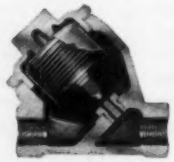
Tight Shut-off



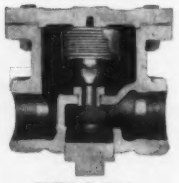
TYPE A-200 Freeze-Proof



TYPE C-250 Freeze-Proof



TYPE Y-200



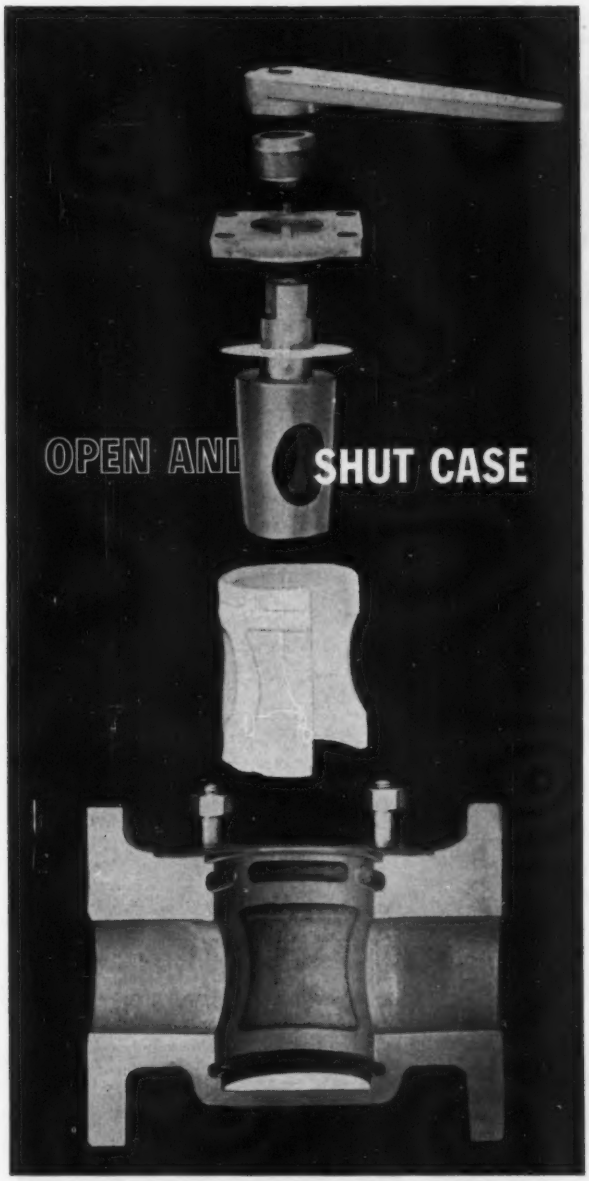
TYPE B-250

For additional information contact

FRANK D. RIGGIO CO., INC.

State Highway 17, Rutherford, New Jersey

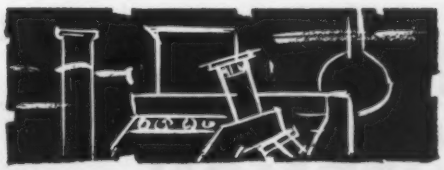
Phone Webster 9-8450



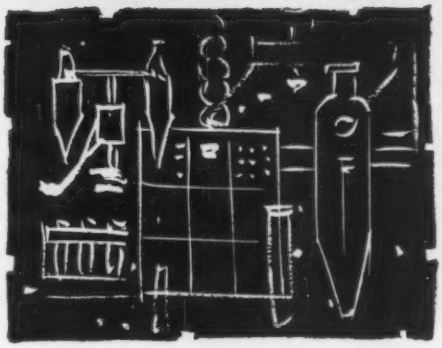
Leakproof sealing without maintenance in ON-OFF service makes an open and shut case for specifying Continental's TUFLINE non-lubricated plug valves. ■ For the facts of the case, examine closely the special high pressure sealing ribs and carefully sculptured body bore configuration. This, combined with the specially tempered pure Teflon* sleeve and tapered plug, is where Tufline valves pay off... in bubble-tight sealing without plug adjustment even under fluctuating temperature conditions. ■ For complete information on Tufline valves ¼" through 10", 150# and 300# class, 2-way through 5-way, or jacketed, furnished in a wide range of metals for services from light hard-to-hold gases to heavy corrosive slurries, temperatures –150° F. to + 400° F., high vacuum to 615 psi (depending on temperature), write Continental Mfg. Co., 230 Park Ave., New York 17, N.Y. *Registered trademark of E. I. Dupont de Nemours & Co., Inc.

TUFLINE PLUG VALVES

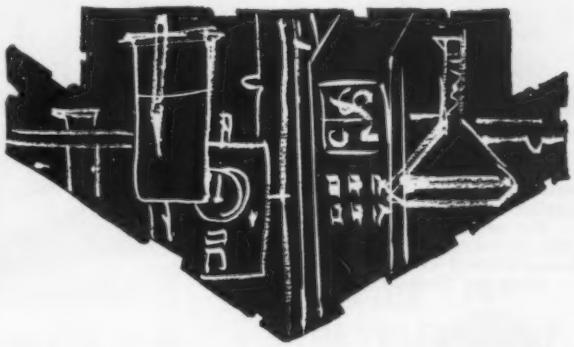
CONTINENTAL MANUFACTURING COMPANY • CINCINNATI 42, OHIO



EVERYTHING FOR THE PETROLEUM LABORATORY



Curtin's conveniently located warehouses throughout the South and Southwest have everything for the petroleum laboratory in stock and ready for immediate delivery. Repair service and technical assistance are always available to Curtin customers. Save time and money by ordering all your laboratory requirements from Curtin, where complete stocks and facilities assure you of the best service.



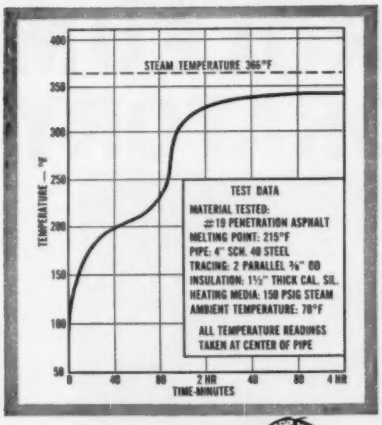
W. H. CURTIN & CO.

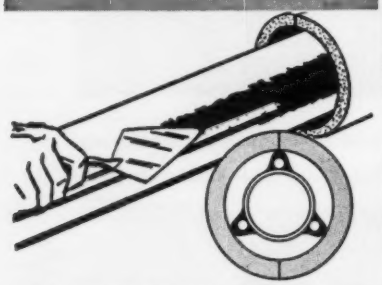
PETROLEUM TESTING EQUIPMENT

HOUSTON • DALLAS • TULSA • NEW ORLEANS
JACKSONVILLE • BIRMINGHAM • CORPUS CHRISTI
CURTIN DE MEXICO, S.A. DE C.V., MEXICO, D.F.

112

Eliminate Asphalt heating problems with THERMON HEAT TRANSFER CEMENT


STEAM TEMPERATURE 366°F
TEMPERATURE — °F
TIME-MINUTES
TEST DATA
MATERIAL TESTED: #19 PENETRATION ASPHALT
MELTING POINT: 215°F
PIPE: 4" SCH. 40 STEEL
TRACING: 2 PARALLEL ¾" OD
INSULATION: 1½" THICK CAL. SIL.
HEATING MEDIA: 150 PSIG STEAM
AMBIENT TEMPERATURE: 78°F
ALL TEMPERATURE READINGS TAKEN AT CENTER OF PIPE



On seventy miles of asphalt line, some fifty refineries have used Thermon Heat Transfer Cement to eliminate the physical problems and expense of internal tracing and steam jacketing. A non-metallic, adhesive compound with highly efficient heat transfer characteristics, Thermon Heat Transfer Cement used on asphalt lines and equipment

Eliminates stuffing boxes and packing glands

Eliminates the possibility of cross contamination

Reduces considerably both installation and maintenance cost

Eliminates misfitted prefabricated jacketed piping.

Thermon can be used successfully on pumps, valves, pressure and differential pressure transmitters, flow measuring instruments, lab apparatus and pilot plant equipment in service with wax, lube oil, heavy greases, alkylates and #3-#90 penetration asphalt.

For existing or future asphalt installations, investigate the benefits of Thermon, the *proved* solution to heat transfer problems.

Write for Thermon Engineering Data.

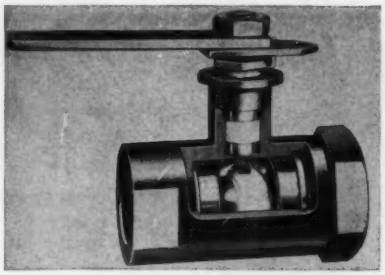
THERMON

THERMON MANUFACTURING CO.

1017 Rosine • P. O. Box 1961
Houston, Texas

120

New Equipment . . .



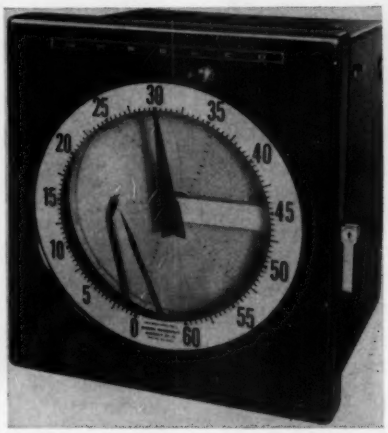
practically any fluid features an adjustable stem seal, a self-adjusting ball which seals with flow in either direction, and stem shoulder to prevent the ball from being forced downward.

The line includes valves with Navy G bronze or semi-steel cast bodies; or brass, steel, and 303 or 316 stainless steel bar stock bodies. Both the cast and bar stock types have full-round, pipe-sized passage for fluids, or restricted passage as desired. Offered with flexible self-forming Teflon seats and seals, they will soon be offered in other materials such as: rubber, polyethylene, or Kel "F". Sizes range from ¼ to 2½ inches for pressures up to 400 pounds water-oil-gas, and temperatures to 450° F. Homestead Valve Mfg. Co.

Circle E20 green card, last page

Temperature Controller Is Self-Contained Unit

A new line of round chart recording and indicating controllers, called Double-O, are completely self-contained, null-balancing instruments requiring only an external sensing device. A wide range of



models are available for the measurement, indication, control and permanent recording of temperatures. With proper circuitry and the use of transducers, such variables as speed, strain, hydrogen ion (pH) and other quantities which can be resolved into electrical signals can be recorded and controlled.

The swing-away design allows easy access for quick change of range, control form, cross chart speed, charts and all major or adjustable components.

A bold-figured 32-inch scale means easier reading. The scale is stationary, only the set point and control point move.

This new line gives ½ of 1 percent accuracy for all scale spans in pyrometric range. Barber-Colman Co.

Circle E21 green card, last page

For Uniform QUALITY

Specify CHICAGO-WILCOX GASKETS

RING GASKETS

For ring-type flanged joints in high-pressure lines. Made of soft iron, standard steel alloys or any non-ferrous metal to any desired cross section. Ask for Bulletin 563.

HEAT EXCHANGER GASKETS

Made in any size or shape needed in double-jacket type. Also cut from solid metal or sheet packing. Ask for Bulletin 564.

CORRUGATED METAL GASKETS

Plain or jacketed type. Made of ingot iron, aluminum, stainless steel, copper, brass, nickel and monel in all sizes and shapes. Ask for Bulletin 565.

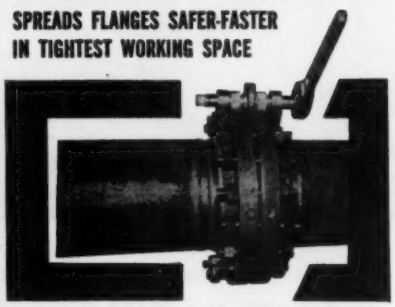
Write for Literature and Discounts

Prompt Deliveries

CHICAGO-WILCOX Mfg. Co.
7719 So. Avalon Ave., Chicago 19, Ill.

"SAFETY BOY"

SPREADS FLANGES SAFER-FASTER IN TIGHTEST WORKING SPACE



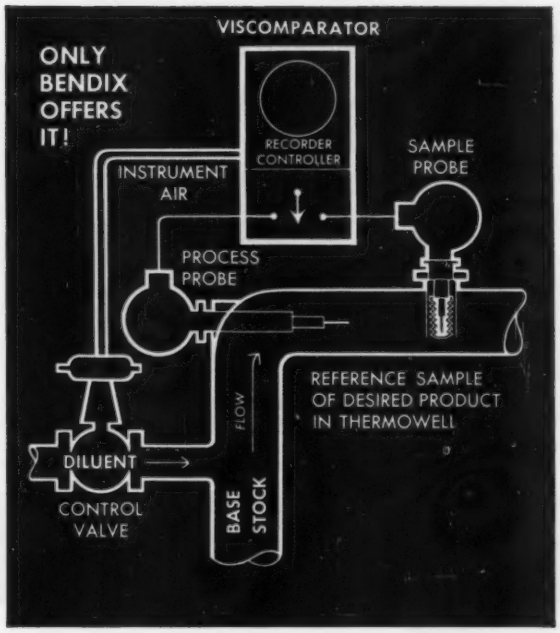
- Eliminates plant safety hazards and costly down time.
- Spreads all Series pipe flanges. Spreads ring joint flanges.
- Lightweight / Priced right

FOR CATALOG SHEET: WRITE TO

Wm. L. Riggs Co.
600 S. 129 E. Ave., Tulsa, Oklahoma

BENDIX® VISCOMPARATOR®

Provides precise, continuous viscosity control for fuel oil blending, asphalt cutback



The Bendix Viscomparator* is a highly efficient blending process control instrument. It provides continuous and accurate measurement and control of liquids to assure specification viscosity.

A computer and control unit receive signal information from probes in the reference sample and the process sample. A recorder supplies visual indication of viscosity agreement. When difference signals are received, the control unit automatically provides proportional, reset, and rate action to effect the desired control of the process variable.

Temperature compensation is built into the Viscomparator's design. The sensing element is rugged—withstanding up to 650°F. and 1,000 psi.

The Viscomparator is ideally suited to fuel oil blending, asphalt cutback, and similar petroleum processing operations. With a Viscomparator Multipoint Unit, additional probes may be used for multiple-operation control.

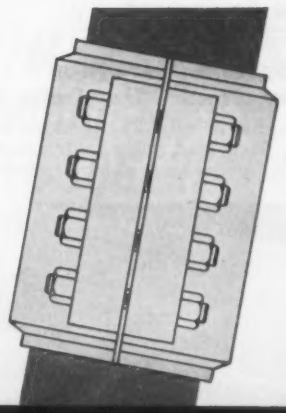
For complete information about this precise viscosity control system, write Dept. W3.

*TRADEMARK

Cincinnati Division
3130 WASSON ROAD, CINCINNATI, OHIO

THE Bendix CORPORATION

Export Sales and Service: Bendix International Division, 205 East 42nd Street, New York 17, New York
Canada: Computing Devices of Canada, Ltd., Box 508, Ottawa 4, Ontario

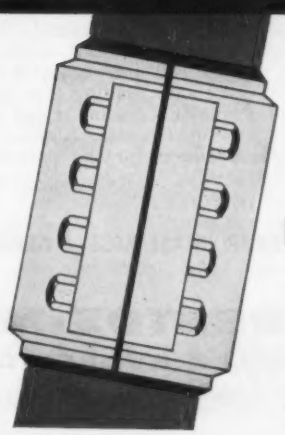


Completed Installation

FAST, SAFE PIPELINE REPAIRS WITH NEW SMITH SPLIT-COUPLING

The Smith Split-Coupling can be used as coupling, repair clamp or split sleeve.

Easy installation—Place halves around pipe. Tighten side bolts. **Permits welding while pumping.** Available in standard pipe sizes. Extra lengths and special dimensions on application.



Completed Installation (When welding is specified)

THE PIPE LINE DEVELOPMENT COMPANY

5700 Detroit Avenue
Cleveland 2, Ohio

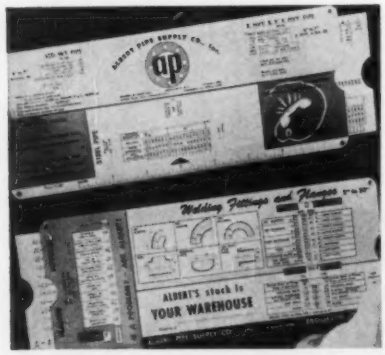
REPRESENTATIVES THROUGHOUT THE WORLD

For more data on advertised products, use Readers' Service Cards, last page.

New Equipment . . .

Slide Rule Gives Pipe Flange and Fitting Data

An easy to use, 10-inch slide card gives pipe, flange and fitting information in a handy, permanent slide-rule-type card.



On one side are tables on pipe sizes, schedule number, wall thickness, weight per foot and pressure at yield on pipe from ⅛ to 24 inches. On the reverse side of the card are data on welded flanges and fittings—size (2 to 30 inches), dimensions and weight per piece. Data on cast iron and steel-flanged fitting, sizes 2½ to 18 inches, are also presented. Albert Pipe Supply Co., Inc.

Circle E22 green card, last page

Bulletin Offers Relief, Back Pressure Valve Data

Reliance Type ASO relief and back pressure valves, designed for high sensitivity at low pressures, are described in Bulletin 115. The valves are recommended for back pressure service on vapor recovery and butane systems and similar applications involving relief pressures as low as 3 inches w.c.

Cut-away drawings show interior design of Type ASO-1 (small) which is available in sizes ⅜ to 1¾ inches, and Type ASO-1 (large), available in sizes 1¾ to 2 inches. Relief capacities, dimensions, and weights are given in tabular form. American Meter Co.

Circle E23 green card, last page

Fundamentals of Frequency Response Covered in Paper

A member of the company's research staff has prepared a 12-page bulletin on "Fundamentals of Frequency Response." The paper is intended to provide the practical instrument man with a rudimentary knowledge of the terminology and a basic understanding of this relatively new technique in the control field. Fisher Governor Co.

Circle E24 green card, last page

Electrical Equipment Catalog Guides Buyer

The latest "Buy Log," a 92-page catalog covering low-voltage distribution equipment, is designed to provide complete buying information on heavy-duty safety switches, CLF current-limiting fuses, hinged wireway, circuit breakers, switchboards, motor control centers, power distribution centers, and all types of panelboards and busway.

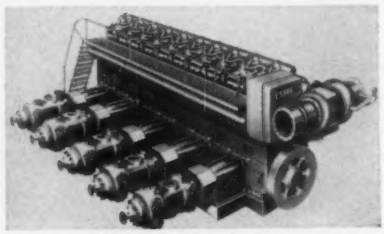
Among the many features of this useful publication are: product selector charts, descriptions, consolidated pricing tables, and a catalog number index.

Also included are ratings, weights, dimensions, standard package quantities, ordering directions and general application information. General Electric Co.

Circle E25 green card, last page

Gas Engine Compressor Modified for 1500-3000 hp

A new modified version of the popular Model TLA gas-engine-driven compressors for the 1,500-3,000-bhp range, desig-

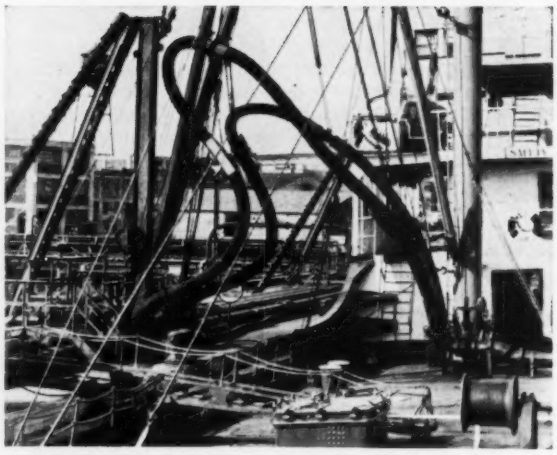


nated Model TBA with 17 x 17-inch bore and stroke will supplement the TLA in intermediate horsepower steps. It will be

ONLY R/M PARANITE LOADING HOSE OFFERS ALL THESE LONG-LIFE FEATURES

- **HYCAR TUBE**—Oil-Proof and High-Octane Resistant.
- **UNIFORM BORE**—assures Rapid Flow—Suction or Discharge.
- **NEOPRENE COVER**—Oil, Abrasion and Weather Resisting for Long Wear.
- **TYPE "C" LEAK-PROOF FITTINGS**—Built into the hose as an Integral Part—*no clamps required.*
- **SQUARE-WOVEN DUCK PLY CONSTRUCTION**—engineered for *Safe* Flexibility and Stress Resistance under Pressures.

Reduce dock time with the combination suction and discharge hose recognized for the highest standards of performance, safety and long service life. Available in 7 types for pressures up to 200 psi—smooth-bore, rough bore, for sea and dock ship loading and barge service. Ask about the Paranite Loading Hose construction engineered for *your* operations . . . and other performance-proved R/M products for the petroleum industry.



R/M ROTARY HOSE / MUD PUMP INTAKE HOSE / VIBRATION HOSE / NON-BURSTING STEAM HOSE / PILE DRIVER HOSE

RM 107

RAYBESTOS-MANHATTAN, INC.
MANHATTAN RUBBER DIVISION • PASSAIC, N. J.
ENGINEERED RUBBER PRODUCTS

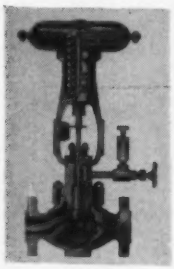
built in five, six, eight and ten-power cylinder models rated at 1500; 1,800; 2,400 and 3,000 bhp respectively. These sizes combined with TLA units rated at 1,700; 2,000; 2,800 and 3,400 bhp, offer a full range of models to meet any pipeline or process requirement. Clark Bros. Co.

Circle E26 green card, last page

No Leakage With Control Valves Using Soft Seats

Soft seat plugs which provide tight shutoff without sacrificing flow characteristics or capacity have been developed for the company's 20,000 Series control valves.

Design of the plugs is such that there is metal-to-metal backup for the soft seat inserts which, in closed position, are fully retained and will withstand differential pressures in excess of 1,000 psi.



Inserts of Buna-N, Teflon and glass-filled Teflon are available. Buna-N is recommended for applications where temperature does not exceed 200° F; Teflon for temperatures to 300° F and for chemical service; glass-filled Teflon for temperatures to 500° F, for applications requiring high mechanical strength and corrosion resistance and for steam service. Mason-Neilan.

Circle E27 green card, last page

Calculator Finds Pump hp And Pipe Diameter Needed

A new circulator calculator made of plastic for finding the pressure drop and horsepower was designed by the company's chief engineer to help engineers decide on the right bore of pipe and horsepower needed when planning a pumping installation.

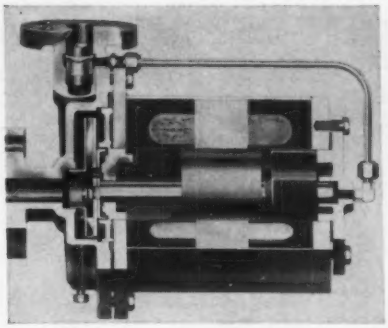
To find the pressure drop, the dial is set for a known viscosity against the pipe diameter and the pressure drop is read opposite the required flow rate.

By setting the delivery pressure against the pump output, the horsepower input can be read opposite the pump efficiency. Plenty & Sons, Ltd.

Circle E28 green card, last page

Leak-Proof Canned Pump Has Longer Bearing Life

A new line of leak-proof canned pumps whose exclusive automatic thrust balance design is combined with larger bearings and more than triple radial bearing surfaces gives extremely long bearing life. Motor life of the new Series G Chempump is greatly extended by an oil-filled stator cavity that dissipates heat from motor windings much more effectively than ever before possible. In addition to providing longer maintenance-free pump life, these new pumps incorporate production techniques which enable them to

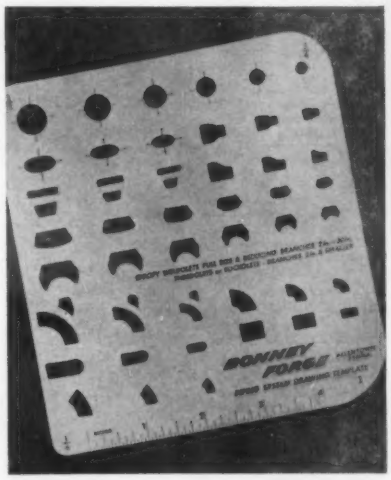


be offered for sale at substantially lowered prices. Chempump Div., Fostoria Corp.

Circle E29 green card, last page

Welding Template Includes Most Common Pipe Shapes

A new free piping system welding fitting template includes the most commonly used welding fitting shapes. The



template was prepared in cooperation with and for piping designers, to speed design and drawing time on welded piping systems. Bonney Forge and Tool Works.

Circle E30 green card, last page

Liquid Level Gauge Calibrated to 1/16 Inch

A bulletin on the new Varec Figure No. 8400 Series high-pressure "Dynamatic" liquid level gauge explains the operation and unique features of this electrically-powered tank gauge which is calibrated to 1/16 inch.

The electric power drive in the gauge eliminates errors caused by friction, and use of a displacer does away with float problems. In addition, the new gauge is said by Varec to be lower in cost than any other high-pressure, power-operated gauge now available. The Vapor Recovery Systems Co.

Circle E31 green card, last page

R/M CAPABILITY PRODUCES VEE-SQUARE® PACKINGS

to eliminate sensitive gland adjustments

R/M Vee-Square Packings combine the advantages of jam type packing rings with the automatic sealing of V-ring design. They take tight gland pressure, require no sensitive adjustment. And blowby is prevented by the soft rubber cushions between rings. Each ring in a set acts individually during normal life and pressure does not pyramid.

Write for your copy of "R/M Products for the Petroleum Industry," Catalog P-8904, covering Vee-Square and other mechanical packings.

RAYBESTOS-MANHATTAN, INC.
R/M PACKINGS
PACKING DIVISION, PASSAIC, N.J.
MECHANICAL PACKINGS AND GASKET MATERIALS

For more data on advertised products, use Readers' Service Cards, last page.

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KOCH FLEXITRAYS—USED 100% IN LARGEST U. S. PROPYLENE PLANT

SUN OIL COMPANY'S $2,000,000 PROPYLENE PLANT – recently placed in successful operation at Sun's huge Marcus Hook, Pennsylvania, refinery – has a potential capacity of 120,000,000 pounds of high-purity propylene per year. Reputedly the largest operation of its kind in the United States, designed to produce the high-purity propylene required by manufacturers of polypropylene – Sun's new plant is currently producing a material with 99.9% purity from refinery gas streams. KOCH FLEXITRAYS HELP MAINTAIN THAT PURITY! Type "F" Koch Flexitrays—140 in all – were specified 100% in the two distillation towers that comprise the major equipment in the new plant. Considered the most dependable and economical device yet developed for distillation absorption and stripping, Koch Flexitrays often save refineries and chemical plants 20 to 40% on total cost of completed installations! For YOUR next tower – investigate Koch Flexitray before you specify! The extreme flexibility of this low-cost fractionating tray has led to its use in more than 1700 installations.

See our catalog in "Refinery Catalog" — or contact your nearest Koch representative.

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Denver, Colorado, G. M. Wallace & Co., 324 Denham Bldg.
El Paso, Texas, G. M. Wallace & Co., 511 Electric Bldg.
Houston, Texas, Alpha Engineering Co., P. O. Box 12371
Kansas City 13, Missouri, Sample Brothers, P. O. Box 7061
New York 17, N. Y., F. J. McConnell Co., 60 E. 42nd St.
Oakland, Calif., Engineered Process Equip. Co., 600 16th St.
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Pasadena, Calif., Engineered Process Equip. Co., 774 E. Green St.
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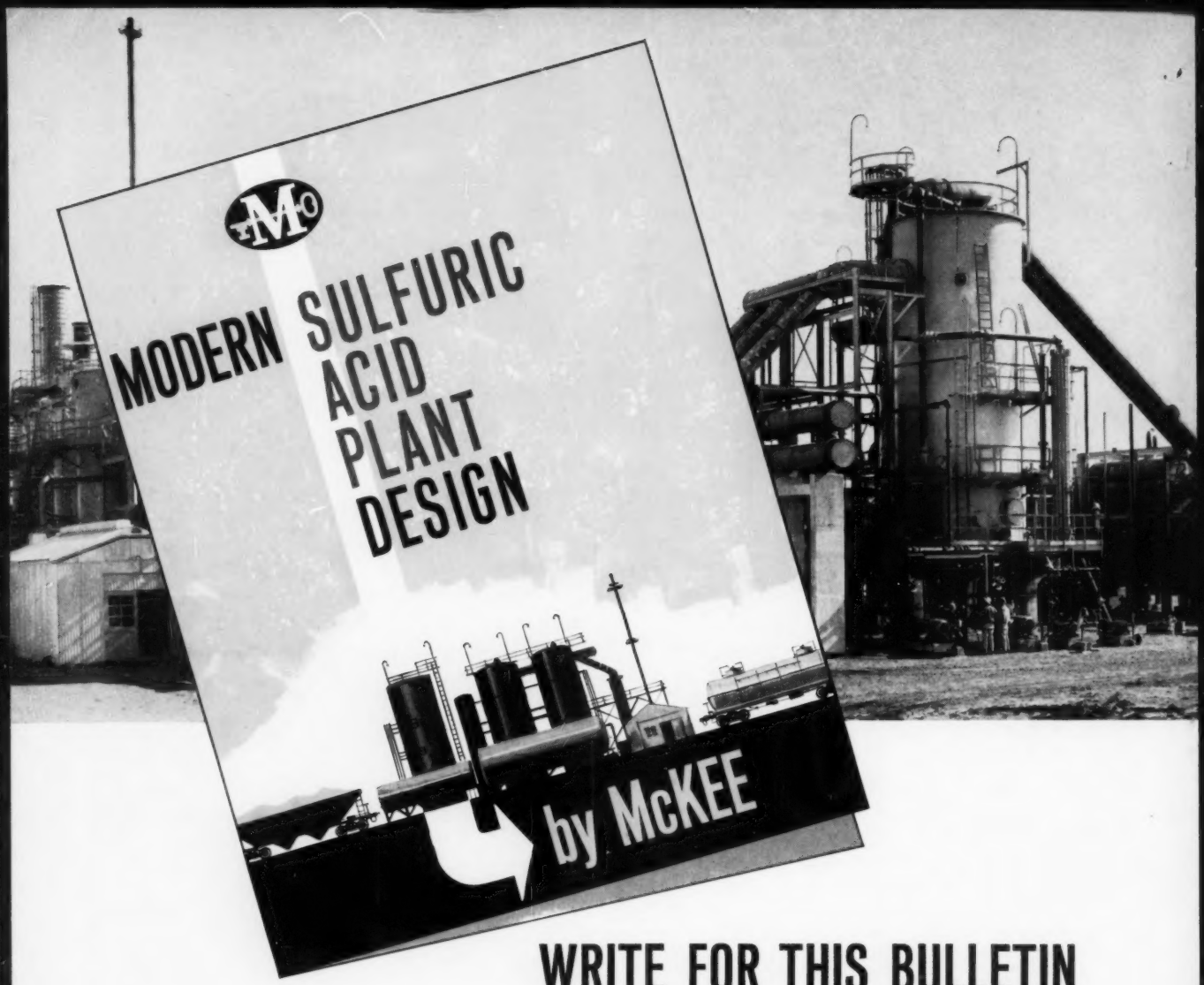

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It shows you how the new McKee design, based on comprehensive engineering studies, effects impressive reduction in plant cost

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